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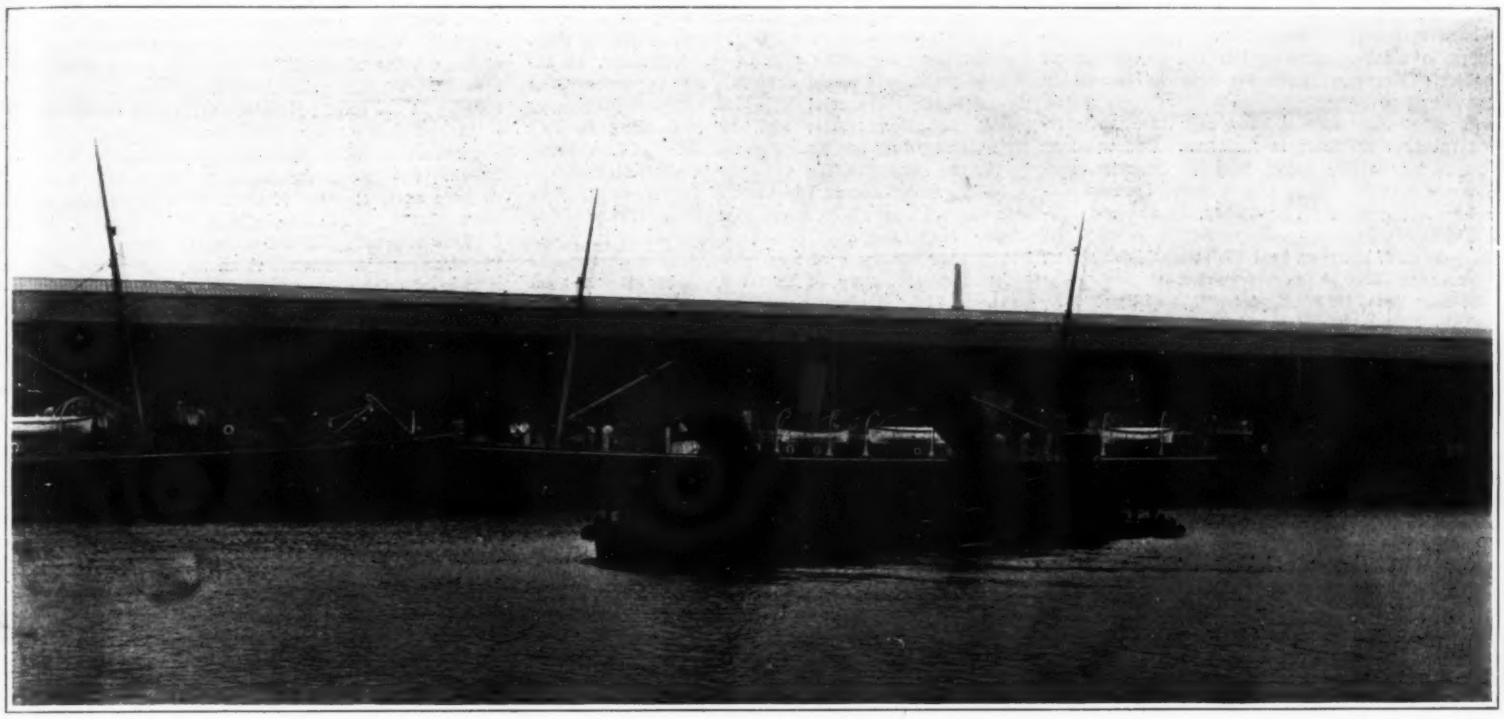
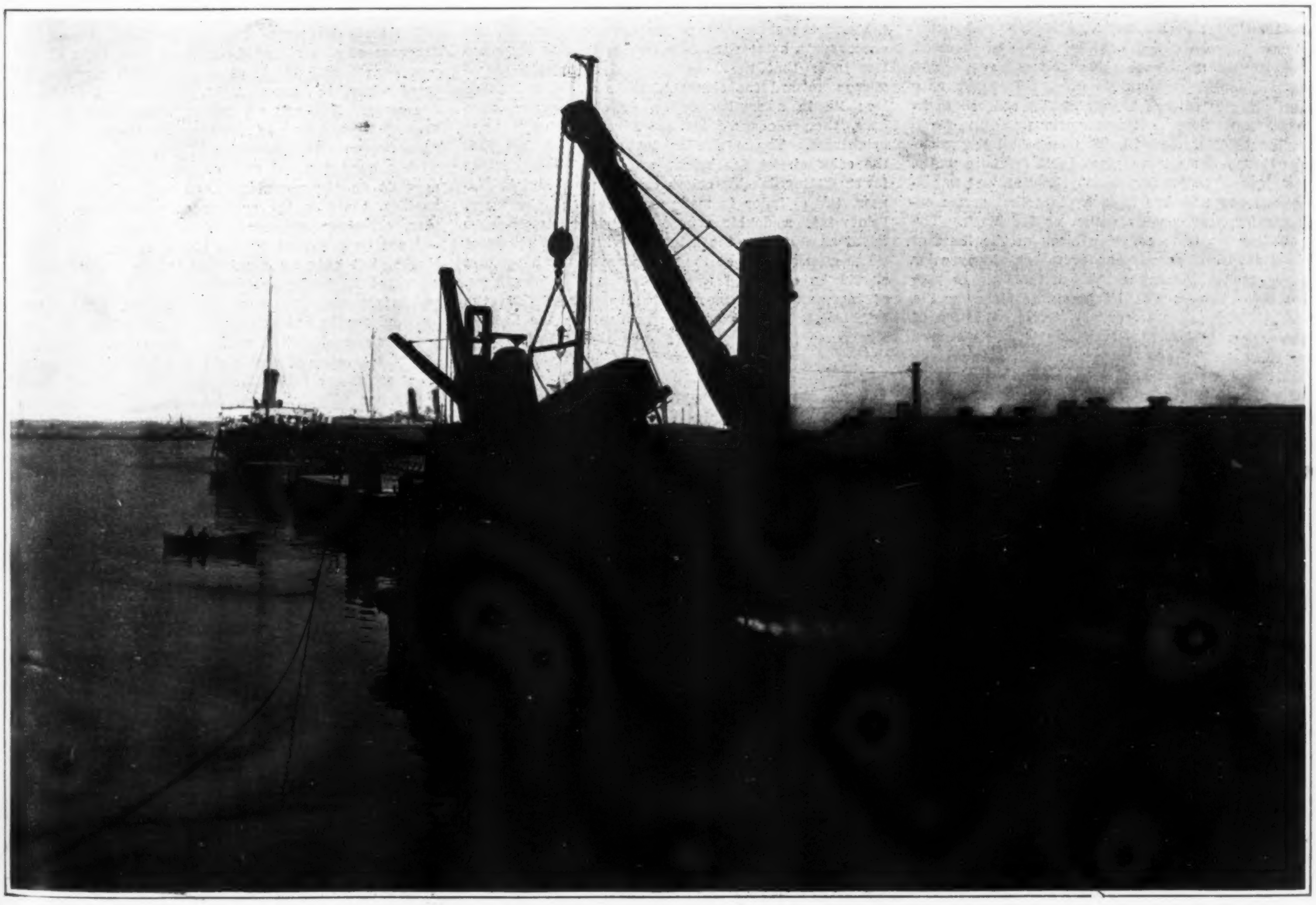


Fig. 1—The Coaling Barge "Herald."



The Usual Method—A Cloud of Coal Dust Envelops Everything Around.

MODERN METHODS OF BUNKERING STEAMERS.—[See page 388.]

The Psychology of Light.—I.*

The Subjective Aspect of Optics

By Prof. R. S. Woodworth

IN a strictly logical division of the science of light, what concerns the purely objective processes would be assigned to physics to physiology whatever concerns the action of the retina and its nervous connections, and to psychology the sensations of light and the utilization of light in perceptions and various other mental performances. Any such division of the field is, however, artificial; for the physicist and physiologist have to approach their objects of study through the medium of sensations and perceptions, and they have accordingly been among the foremost contributors to what is theoretically the psychology of the subject. Moreover, the psychologist gains nothing by attempting to keep his treatment purely psychological; for what one wants to know is facts in their relations rather than facts in isolation. Consequently the psychology of light, as usually presented, contains much that might equally well be brought forward by the physicist or, especially, by the physiologist.

It may be said, however, that the psychologist starts, by preference, where the others start from necessity—namely, from sensations and perceptions of light. Suppose that, without knowing anything of the physics of light, one has at his disposal an abundance of bright, dark and colored objects of every shade and hue, and preferably of the same sort of material, such as paper or silk. The observer of such a collection of objects not only sees a great variety of colors, but he easily notes degrees of resemblance among them, and is able to divide them into groups, or, still better, to arrange them in series. Thus he can arrange a graded series running from white through light and dark gray to black; and, though with more certainty, he can arrange the whole collection of colors in a series ranging from light to dark. This arrangement may be called the light-dark series, or the brightness series. Besides this, the observer notes differences of color, and if he start with a pure yellow and a greenish yellow, he can easily continue the series to green and blue and violet and purple and red and orange, back to yellow again. This circular series is truly a remarkable phenomenon, the like of which does not occur elsewhere in the field of sensation, though it has some analogy to the octave in musical tones. Once the color circle is constructed, it is possible to make each color in it one of a brightness series, containing the tints of one color only. Thus a large share of colored objects can be reduced to an orderly arrangement in two dimensions.

But the color circle will not include all our variegated objects; there is no place in it for pure white, black or gray. In passing from yellow around to yellow again, one nowhere finds a place that seems appropriate for gray, or for white, or for black. The best one can do is to consider black as the limit of the dark shades of some color, or rather of any color whatever, and white as the limit of the light or pale tints of any color; but still there is no place for the grays. A more deliberate survey of the collection of colored objects might however enable the observer to find a place for any given gray by taking it as the limit of a series of gradations of any color, gradations which, while preserving the same color tone and the same brightness, differ in the strength of the color, grading down from the strongest or fullest color obtainable at a given brightness, through duller and duller shades of the same color tone and brightness, towards the neutral gray. This is the saturation series, and its limits are on the one hand the most saturated color of a given brightness, and on the other hand a gray of the same brightness. The same gray would stand as the limit of a saturation series for any color tone, and different shades of gray might stand as the limits of different saturation series of the same color, but of different brightnesses. Though less obvious to the observer than the brightness or the color series, these saturation series can be detected by reference to sensations alone, without knowledge of the physics of the matter. But whereas there is essentially but one brightness series and but one color series, there is an indefinite number of similar saturation series, according to the brightness of the gray chosen as the limit, and according to the tone of the saturated color chosen as the other limit.

Since sensations of light and color can be arranged in these three ways, according to color tone, according to brightness, and according to saturation, it is natural to attempt a synthesis of all three arrangements into some composite scheme. No two-dimensional scheme will accomplish this synthesis, but it is possible to do it in three dimensions. If all the color tones which agree in brightness and in saturation are first arranged around the circumference of a circle, a gray of the same brightness may be located at the center of the circle, and along each radius may be arranged the saturation series of a given color, grading from neutral gray to the greatest saturation occurring at the given brightness. Thus the plane of the circle will contain all the colors, including gray, which have the same brightness. Similarly, in another plane, one might construct another color circle of another brightness, with its corresponding gray and saturation series; and, by proceeding in this way, and piling the planes in the order of brightness, with the corresponding color tones always in corresponding positions on the various circles, one should finally include all possible sensations of light and color in a single three-dimensional scheme, which may take the form of a cylinder, bright on top and dark beneath, gray at the center and saturated on the outside, red along one element of the convex surface and blue along another. Practically, to be sure, there is some difficulty in assigning to each color its exact position in this cylindrical diagram, since, though grays and the shades of any one color can be arranged with considerable assurance in the order of brightness, and though colors of the same tone and of the same brightness can be readily arranged in the order of their saturation, it is subjectively difficult to make sure of equality of brightness or of saturation between colors of differing tone. Theoretically, however, every sensation of light and color would find a fixed place in the cylindrical scheme.

It is customary to refine a little on the cylinder in such a way as to do justice to certain minor facts regarding the relations of the sensations to each other. Thus, while the colors of any given brightness and saturation can be arranged in a color circle, the circle will not contain so many distinguishable steps, or barely noticeable differences of color tone, when the brightness is very low or very high, or when the saturation is low, as when the brightness is medium and the saturation as great as possible. As far as concerns saturation, this fact is already done justice to in that the less saturated colors are placed always toward the center of their circle, and therefore lie in a smaller space, or shorter circumference, than the more saturated colors of the same brightness. To do similar justice to the fact that the color circles for bright and dark colors contain fewer distinguishable colors than for medium brightness, the cylinder is made to taper both above and below into a double cone. No red or blue can be found as bright as the brightest white, and therefore white stands alone at the upper apex, which perhaps should be continued upward into a line of whites, of increasing brightness and all brighter than the brightest color. No color is as dark as the deepest black, and therefore black stands alone at the lower apex, and possibly this also should be prolonged into a line.

A still further refinement is sometimes introduced. To some observers, the color circle is an imperfect diagram, because it seems to indicate a perfectly gradual and uniform change of color tone throughout the series. They seem to notice certain turning-points at which the series alters in character or direction. From red through orange to yellow, the series appears to them homogeneous throughout, and is properly represented by a straight line; but as soon as yellow is passed, and a tinge of green appears, the series has taken a turn and started off in a new direction, namely, toward green. To some observers it seems proper to discard the circle for a square, with four somewhat rounded corners at red, yellow, green and blue. Others are unable to detect any turning-point in the red or green, but only in the yellow and blue; while others still are unconvinced of any such turning-points at all. Different observers differ also in the exact location of the turning-points, and it may reasonably be doubted whether, with a sufficiently great number of colors at hand, graded by equal fineness throughout the series, any turning-points would appear to exist. At any rate, whether the square be substituted for the circle, and the double pyramid for the double cone, or not, is a question of minor importance, since all the main facts are equally well schematized by either diagram.

The fact should not be overlooked that these diagrams are not intended to indicate anything regarding the stimuli arousing the sensations. What is indicated is simply the possibility of arranging colors in series according to brightness, saturation and color tone, with no regard to the physical or physiological processes which arouse these sensations. The color pyramid is a purely psychological affair. If psychology were kept absolutely pure, that is limited to the study of sensations and other states of consciousness and isolated from their physical conditions and effects, then the present paper should be concluded at this point with the addition of some comment on the æsthetic value of the different colors: apart from this all the perfectly pure psychology of light is summed up in the color pyramid; everything else involves some knowledge of the stimulus which gives rise to the sensation and of the relation of stimulus to sensation. Few psychologists, however, care to remain so pure as this; most of them wish to advance to a knowledge of conditions, effects and other relations. But, at any rate, the system of facts symbolized by the color cone or pyramid is an important part of the science of light.

Starting out from the three-dimensional system of sensations of light, one naturally inquires next as to the corresponding dimensions of the physical stimulus. But soon one is convinced that there are no dimensions of the stimulus corresponding precisely to the scales of color tone, brightness and saturation. In a rough and general way, one finds that the scale of color corresponds to the scale of wave-length, the scale of brightness to the scale of intensity or energy of the stimulus, and the scale of saturation to the degree of purity of a single wave-length as contrasted with the admixture of other wave-lengths. Thus, light having a wave-length of 700 millionths of a millimeter and thereabouts gives the sensation of red, light of 589 millionths gives the sodium yellow, etc.; light of small physical energy gives a dark color while light of great intensity gives a bright color; light that is homogeneous or monochromatic or, in other words, all of one wave-length, gives a saturated impression while light compounded of rays of various length gives an unsaturated color or even a neutral gray or white.

But these correspondences are far from perfect. In the case of saturation, if one start with light of one wave-length, and add to it, or blend with it, more and more white, i.e., mixed light, the saturation will be decreased. But not all homogeneous light gives a saturated sensation; as, for example, the pure sodium light produces an impression of paleness as compared with a good full red or blue. Saturation, therefore, depends on the wave-length, as well as on mixture. Besides, there is the curious case of purple, which may, certainly, appear saturated enough, though it can not be produced by the action of any one wave-length, but only by a mixture of long and short waves. Still further, saturation, as well as color tone and brightness, depends on the duration of the stimulus, and on the character of the light which has just previously excited the eye. A light which appears highly saturated at first sight grows paler and paler with prolonged inspection; and the most saturated effects can only be obtained by first looking steadily at a bright color, and then turning quickly to a somewhat darker shade of the complementary color.

The case of color tone is even more intricate. In a general way, it depends on the wave-length, but there are many important exceptions to the rule. Just as prolonged fixation of a colored light changes its apparent saturation, it may also change its apparent color. A light which appears orange or greenish yellow at first tends on prolonged fixation to change toward pure yellow, at the same time losing in saturation; and, similarly, a greenish blue or a violet changes toward blue. Yellow and blue themselves do not change except in saturation. There are a particular bluish green and a particular purplish red which, also, do not change in color, but only lose rapidly in saturation, verging towards neutral gray. This red and this green are boundaries, as it were, between the spheres of influence of yellow and blue. On the color circle they may be taken as extremities of a diameter, separating a yellow from a blue semicircle. To the fresh eye, the yellow half appears graded in color from purplish red through red, orange and yellow to green. The blue half appears graded from bluish green through blue, violet and purple. But when the eye has become sufficiently fatigued or adapted by prolonged exposure of the same parts of the retina to the same lights, then the yellow half of the circle appears yellow throughout, and the blue

* Reprinted from the Transactions of the Illuminating Engineering Society.

half blue throughout, though varying in saturation.

Color tone depends on the intensity of the physical light, as well as on its wave-length. If the intensity is sufficiently diminished, then, though the eye be allowed time to become well adapted to the dark, the distinction of color drops out, and only grays are left. Also, it is said, if the intensity of monochromatic light is sufficiently increased, not only do all the colors lose in saturation, but all except blue and yellow tend to shift toward one of these two colors, much as in prolonged fixation. Here again there are boundary colors between the yellow and the blue halves, and the boundary colors do not shift in color with increasing intensity, but only lose saturation and pass into white.

Color is also dependent on the size or area of the stimulus, since a minute area of color is likely to appear colorless, though a larger area of the same character would show its color.

There is still another exception to the rule of correspondence between color tone and wave-length, and it is a very curious exception, that is, color mixture. The sodium yellow, for example, can not only be produced by light of 589 wave-length, but also by the combined action of 650 and 550 in proper proportions, or by many other pairs of rays, one of greater and one of less wave-length than 589, provided only that neither of them differs too much from 589. In general, the same color tone as is produced by light of any given wave-length can also be produced by a mixture of other wave-lengths, one greater and one less than that whose color is to be duplicated. The mixed light does not betray its composition, but gives just as unitary a sensation as homogeneous light. The sensation gives no indication whether the light is homogeneous or mixed, except that, in general, homogeneous light gives a more saturated effect; and the greater the difference in wave-length between the two lights mixed, the less in general is the saturation of the resulting color sensation. But even this rule in regard to saturation has exceptions; so that, in short, it is impossible, from the color effect produced by a light, to infer anything with certainty and precision as to the wave-length or wave-lengths of the light. Reference should also be made again to the purples, which though fully as definite color sensations as any others, have no corresponding single wave-lengths. To the physicist, purple may almost be called a sham and illusion; it has no place in the spectrum, and does not represent any homogeneous ray as the other colors do. Therefore it can not be allowed, in physics, a standing equal to that of the other colors. Nevertheless, as a sensation, purple has exactly as good a standing as any other color. It can not be regarded by the psychologist as a mere mixture of other sensations, for it appears to the observer quite as single and homogeneous as the other colors. It occupies its place in the color circles with the same dignity and assurance as any other color. In every respect it is on a par, psychologically, with other colors.

The grays and whites have somewhat the same curious position as the purples, since these sensations are not aroused by light of any single wave-length, (unless, indeed, it be of very high or of very low intensity), but only by a mixture of different rays. Many different mixtures give the same effect—either a combination of all the rays in the proportion in which they are present in sunlight, or a combination of the two wave-lengths 656 and 492, or 585 and 485, or of 564 and 462, etc.; and also a combination of three, four or more rays properly chosen and adjusted. When two rays combine to produce the sensation of white, they are called complementary, and it is customary also to call the colors corresponding to the wave-lengths complementary colors. Strictly speaking, it is not the color sensations which are complementary, but only the rays of light; for there is nothing in the aspect of blue to indicate that, when combined with yellow, it would give gray; and nothing, indeed, is more surprising than to see for the first time a mixture of blue and yellow, on the color wheel, give rise to the neutral gray, from which all traces of the constituent colors have disappeared. Strictly speaking, again, yellow and blue, as sensations, are not constituents of gray. They have not been blended into the sensation of gray, but have disappeared, making way for the sensation of gray.

Color mixture, in general, is not mixture of color sensations, but mixture of stimuli.

Mixed stimuli give homogeneous color sensations. The same statement could not be made of any other sense than vision. One does not experience a salty taste, for example, by taking into the mouth a mixture of sweet and acid substances; nor is the note *re* heard when *do* and *mi* are sounded together. There is something peculiar about the sense of sight in this respect.

There is still one other grand exception to the rule of correspondence between color tone and wave-length. This correspondence holds, at best, only for the ordinary polychromatic vision, of which the color circle is a symbol. Already mentioned is one instance of achromatic vision, namely, the case of very faint illumination. On passing from bright to dim light, one at first sees very little, but soon becomes adapted to the dark so as to see objects and distinguish the lighter from the darker. But in thus becoming adapted to dim light, the eye does not become adapted to differences of wave-length in the dim light, but all dim light is gray. There are two other instances of achromatic vision. First, there are the totally color-blind individuals, who recognize no distinction of light according to the wave-length. All wave-lengths are alike to them, aside from differences in brightness. The other instance is found in indirect vision with a normal eye. At the very outside of the field of view, lights can not be distinguished in color, but only in brightness, or, at least, only very intense lights can be distinguished in color, all others appearing gray. Another form of vision besides polychromatic vision with its three dimensions, color, brightness and saturation, must therefore be recognized—a form in which the color dimension is suppressed, and with it the saturation dimension, leaving only the dimension of brightness. Instead of a double cone or pyramid, therefore, this achromatic or one-dimensional vision can be symbolized by a straight line. According to the "duplex theory" of vision which seeks to justify these facts, this one-dimensional or mere brightness vision is a function of the rods of the retina, while the polychromatic or three-dimensional vision is a function of the more highly developed cones. This theory finds support in the fact that the achromatic periphery of the retina is almost free from cones, and in the strong indications that totally color-blind individuals are deprived of the functions of the cones. The rods are believed to be more sensitive to very faint light than the cones, or, at least, to be capable of much better adaptation to very faint light. Therefore, in very dim light, seeing only with the rods, one has only brightness and no color vision.

If polychrome vision is three-dimensional, and achromatic vision one-dimensional, one must also recognize the existence of a two-dimensional form known as dichromatic. Two imperfect instances of this form of vision have already been mentioned—that which results from great intensity of the light, and that which results from its prolonged action on the same portions of the retina. In both cases the color circle tends to be reduced to blue and yellow with gray at the boundaries between them. Therefore there is no further need of the circle, since a straight line with blue at one end, yellow at the other, and gray in the middle, provides a place for all the colors experienced in this dichromatic vision. Neither the color dimension nor the saturation dimension is wholly suppressed, but the two coalesce.

More important instances of the dichromatic system are found in indirect vision and in the common type of color-blindness. The outermost part of the retina gives, as has been said, achromatic vision, while the central area gives the complete system of colors. There is, however, an intermediate zone of dichromatism. The limits of this zone, to be sure, are not absolutely fixed, but vary with the intensity of the stimulus. It can be said in a general way that all colors appear, in the intermediate zone, as yellow, blue, or else gray. Scarlet, orange and olive green appear yellow; greenish blue and all the other blues, with violet and purple, appear blue. A certain green, or bluish green, appears neither yellow nor blue but simply gray; and the same is true of a certain purplish red. These are indeed the same boundary colors that were discovered in the previous instances of dichromatic vision. The color circle reduces to two radii, one for yellow in its different saturations, and one for blue, both meeting in neutral gray. The two radii may properly be considered as one diameter, and thus the color circle can be reduced to a straight line, perpendicular to that other straight line which symbolizes the variations of brightness. The double cone or pyramid is reduced to a double triangle.

The most common form of color blindness, best called red-green blindness, is also a dichromatism apparently identical with that of the intermediate zone of the retina. Colors in the yellow half of the color circle are confused with each other to any extent, provided only brightness and saturation are suitably adjusted; and so also all colors in the blue half of the circle may be confused with each other. The boundary colors, often mentioned, are to the color-blind eye indistinguishable from neutral gray. In general, one can not institute a direct comparison between the sensations of the color-blind and of the normal individual; but a few valuable instances are on record of individuals color-blind in only one eye, and their testimony indicates that the colors which remain to the color-blind eye are, actually, yellow and blue, the same as in the intermediate zone of the retina; so that the color-blind possess a two-dimensional instead of a three-dimensional system of sensations of light.

The correspondence between color tone and wave-length, which is entirely lacking in achromatic vision, is partially present in dichromatism, since rays of greater wave-length give one color tone, probably yellow, and rays of short wave-length another color tone, blue. That is to say, any wave-length of over about 500 millionths of a millimeter gives always the same color tone, yellow, though in varying brightness and saturation; and any wave-length less than about 500 gives always the one color tone, blue, in varying saturation and brightness; while rays of about 500 give gray.

(To be continued.)

Tar as a Fuel for Diesel Engines.

In a recent number of *The Engineering Magazine* we find a translation of articles from *Journal für Gasbeleuchtung und Wasserversorgung* and *Die Gasmotorentechnik* on the results of European tests of gas-works and coke-oven tar as a motor fuel.

"Since the expiration of the German patents in 1907, the adaptation of the Diesel engine to operation on tar oil has been attempted by several builders, in some cases with conspicuous success. One Diesel engine of 4,000 horse-power is now operating on tar oil, and units of 600 to 800 horse-power are common. Lately attention has been turned to the possibilities of raw tar for a similar purpose, and very encouraging results are reported from investigations undertaken by the Maschinenfabrik Augsburg-Nürnberg and the firm of Körting Brothers.

"The Augsburg-Nürnberg tests were begun in 1909. Experiments were made on a 100 horse-power engine with both thin inclined gas-retort tar and thick coke-oven tar from Dr. Otto's coking plant. About 2 per cent of the total fuel consumption was a light oil, injected into the cylinder to assist in the ignition of the tar. Ignition and combustion were very satisfactory with both fuels, and the engine showed an overload capacity of 24 to 30 per cent. The experiments have been continued at the Otto plant, where a 100 horse-power Augsburg-Nürnberg engine has been operating on coke-oven tar, under the regular fluctuating plant load, from 6 o'clock Monday morning to midnight on Saturday. It has been found that the use of a lighter fuel for starting is not necessary. With the assistance of a small proportion of ignition oil, the motor starts on tar and runs on tar at all loads. No fouling of the piston has yet been observed and interruptions which might have been anticipated from the nature of the fuel have not occurred.

"The Körting experiments were undertaken at the request of a large corporation operating gas works in a number of German cities, and were restricted exclusively to tars from vertical gas retorts. A 100 horse-power horizontal engine driving a direct-current dynamo was installed alongside the suction gas engines in the power plant of the Körting works. Kerosene was used to assist combustion, and the supply of both fuels was regulated automatically. The proportion of ignition oil used at full load was 2 per cent, at three-quarter load 7.5 per cent, and at half load 13 per cent. It was found possible, though not expedient, to operate the motor at full load on tar alone.

"It appears from the results that the consumption of heat in operation with tar and paraffin oil is about the same as in operation with paraffin oil alone. The motor tested ordinarily consumed about 1,850 calories per horse-power per hour. With kerosene with a heat value of 10,000 calories per kilogramme, and tar with a heat value of about 8,500 calories per kilogramme, the fuel consumption per horse-power per hour was about as follows'

	Tar grammes.	Paraffin oil grammes.
At full load..................	213.3	3.7
At three-quarters load.......	201.3	13.9
At half load	189.3	24.1

"The tars used in the test varied very widely in composition. In one 66-hour continuous run, a wide range of tars was used, without, however, producing smoke or appreciable residue in the cylinder, valves or nozzles. The motor adjusted itself to wide fluctuations of load without variation in speed.

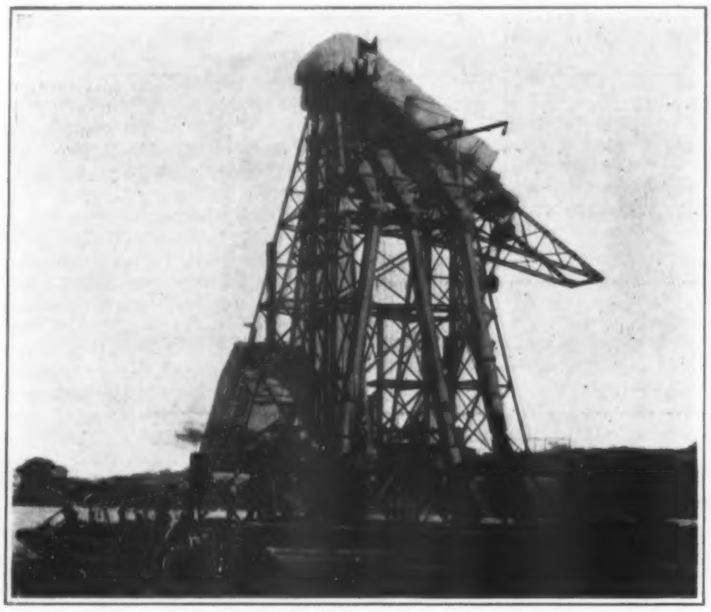
"The cost of a Diesel engine adapted for operation on tar exceeds the cost of ordinary types by about 5 per cent. The fuel cost is about 18 per cent lower than with tar-oil operation, and considerably less than half the cost of paraffin oil. It is reported that a 600 horse-power tar engine has already been ordered from Körting Brothers, and a rapid extension of the use of tar as a motor fuel is predicted."

Modern Methods of Bunkering Steamers

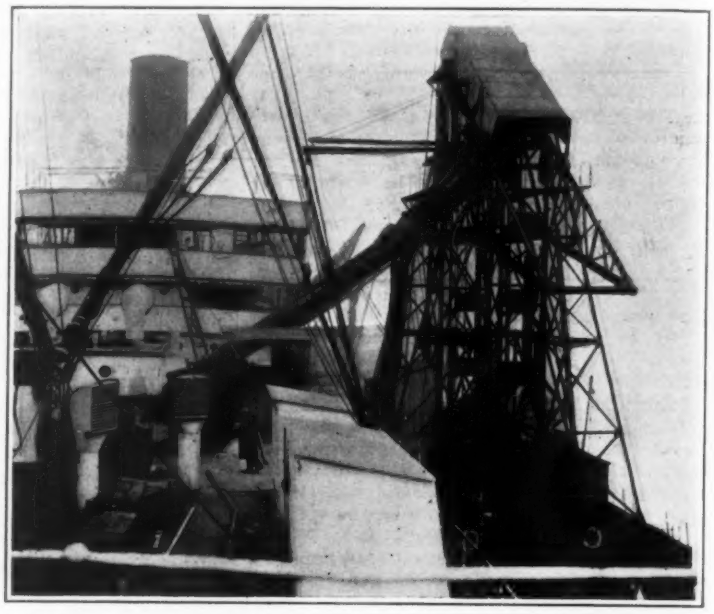
How Speed and Cleanliness are Secured

By F. C. Coleman

In these days of giant steamships, that eat up several thousands of tons of coal on each voyage, the technical problem of bunkering has become one of no small importance. Not only must the coal supply for the impending trip be taken on board expeditiously, but of course it is highly desirable that the operation be performed with the greatest cleanliness and freedom from dust attainable.

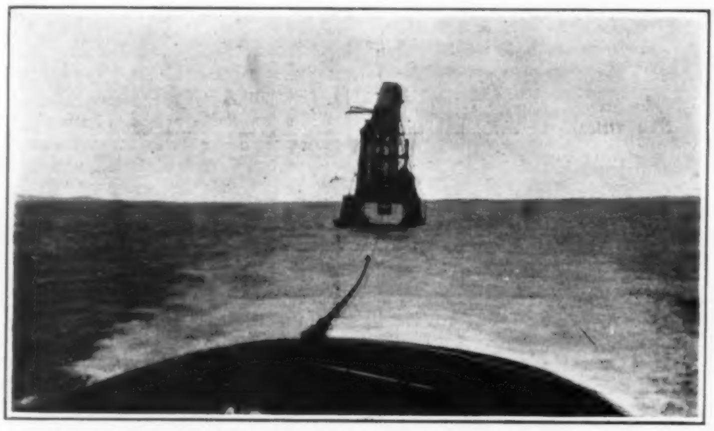


Builders' Trial: Transferring Coal from One Barge to Another.



Coaling and Loading in One Operation, Which is Practically Dust-Free.

Several new departures have been made in the means and methods employed for the large scale transfer of coal from barges to the steamers. Two such instances, which have points of special interest, are illustrated in these pages. The first of these, is represented in a twin-screw coaling boat, the "Herald." This vessel is fitted on the Holland-Johnston system with two elevators, and has a speed through the water of six knots. The capacity of the vessel is 400 tons of coal, and the output 100 tons per hour per elevator, i. e., 200 tons per hour for the vessel. The coal is carried in pockets or compartments on each side of the vessel. Between the compartments and extending nearly from one end of the coaler to the other, is a longitudinal passage up and down which the movable elevators are free to travel. The system is novel and differs from other coaling methods, inasmuch as though the "Herald" has only two elevators, larger vessels fitted in the same way might have three, four or five elevators; and with each of these elevators, having an output of 100 tons per hour, it would be possible for a vessel so fitted to discharge herself at the rate of 500 tons per hour. Large ocean liners served by large vessels of the "Herald" type, one on either side of the liner, such as the "Mauretania" or "Lusitania" and the big vessels of the White Star Line, could thus be coaled at the rate of 1,000 tons per hour.



Towing from Southampton to London in Fifty Hours in Heavy Breeze.

A thousand tons per hour may appear a very large quantity of coal to transfer from barge to steamer, and it can only be done by a system such as that on which the "Herald" is constructed, because an attempt to pass that quantity of coal down one chute, or even two chutes, would mean that the discharge would have to be so rapid that the delivery of it could not properly be taken. In the "Herald" system, however, different chutes are put through the side bunker doors in different parts of the vessel and coaling is thus going on simultaneously in practically all parts of the vessel's bunkers, consequently, the only delay with this method will be at the final trimming in the top of the bunkers, which must always be a slow operation.

End View, with the Adjustable Frame (that goes into the barge) Raised.

The elevators may be moved from any one point in the trunk to another, being carried by the trucks on rails. In addition to this flexibility of the positions of the elevators, the barge itself can, of course, be moved, consequently there is no doubt that any vessel with side bunker doors may be coaled by this design of plant.

When supplying coal to vessels provided with center bunker hatches instead of chutes, conveyors are put into operation for the purpose. With other systems of coaling a great drawback is experienced with the fine coal dust or dirt which gets blown about by the wind and covers the vessel being coaled from end to end with dirt.

By the way of contrast the old method, with its accompanying clouds of coal dust enveloping everything around, is illustrated in our frontispiece. Coaling by means of the "Herald" is a very clean operation. No dust whatever gets on board the vessel being coaled.

The elevators are driven by a very ingenious multiple gear in the top pentagon drum; the small engine necessary for the purpose being contained at the head of the elevator between the top and the bottom trunks. The exhaust steam from this engine is ad-

mitted into the head of the elevator in a suitable position, and is directed along the chutes into the vessel's bunker doors. It was found by experience that coal dust is carried straight into the vessel's bunkers with the steam, thus insuring an extremely clean method of coaling steamers. It is stated that the steam does not in any way wet the coal.

With two elevators, the crew of the "Herald" consists of the master, the engineer, the assistant engineer, a fireman and three deck hands. This crew is sufficient to navigate her and do all that is necessary in connection with the bunkering of steamers. The salient features claimed for this bunkering system are: Flexibility as regards the chutes, cleanliness, rapidity and economy.

An equipment of a rather different character, also designed for the purpose of placing on board the cargo of coal, is a floating elevator designed by Capt. P. H. Suisted, for lifting coal direct from barges and shooting it into a steamer's bunkers. The elevator proper is carried on a superstructure built above two pontoons which lie parallel to each other and 28 feet apart, so that the coal bages when being unloaded can lie between them. The lower pontoons are each 80 feet by 5 feet by 12 feet 6 inches and carry lattice framing about 12 feet high, on the top of which the working deck is fixed. The elevator structure is built up of lattice-work and carries a covered-in hopper at the top, to which the coal is delivered by the elevator buckets. This hopper is fitted with three telescopic chutes. These chutes have universal joints, and may be raised or lowered, and swung fore and aft, their range enabling them to feed either into a bucket hatch 40 feet above the water-line, or into a side-pocket 2 feet above the water-line. The endless chain carrying the buckets, is driven by a tumbler situated at the top of the fixed lattice-work structure, while at the bottom of its path the chain runs round a lower tumbler which is carried by a lattice framing situated inside the main structure. This framing is arranged so that it can be lifted up inside the main structure, leaving a clear way below the deck, so that the barges can be towed into position. When the barge is in place between the pontoons, the framing is lowered until the buckets rest on top of the coal, so that when the chain is set in motion the buckets dig into the coal and lift it to the hopper at the top of the machine, the action being similar to that of a bucket dredger. Buffer springs are fitted to the lifting screws of the framework carrying the lower tumbler, so that movements of the barge, owing to waves, do not interfere with the working of the buckets. When a barge has been emptied, and the lower part of the bucket chain is lifted up level with the deck, the slack of the chain is taken up by two weights operating automatically, which cause the third tumbler round which the main chain works to travel out along a cantilever arm. The elevator is fitted with steam capstans by means of which the barges are towed into position between the pontoons, and, if necesary, are moved forward to suit the buckets while the coal is being removed from them. The capstans are fed from a boiler situated on the deck, which also supplies steam for the bucket-driving mechanism and the lifting-gear. The elevator buckets each hold five hundredweight of coal, and the machine can discharge from 100 to 150 tons of coal per hour down any of the chutes, or the three together. The elevator is designed to deliver coal at the rate of from 100 to 150 tons per hour, but it is, of course, possible to increase the capacity up to almost any point; such expendition is only limited by the ability to dispose rapidly enough of the streams of coal which an appliance of larger proportions would pour into the vessel. It would be quite easy to build a higher machine working into eight places at once, delivering the coal into both sides of a steamer and enabling her to discharge and load cargo at the same time as the coaling is proceeding. As to the saving in the cost of labor, it may be assumed that a gang of five men outside the bunkers would put on board in a day 100 tons of coal at the most, while a Suisted elevator employing seven men is capable of loading 800 tons in the same period, thus performing the work of eight gangs, or 40 men; if, therefore, two machines were placed alongside a steamer, one on each side, working out of the ordinary barges converted into self-trimmers by fitting sloping sides fore and aft 1,600 tons could be loaded in a day with 14 men outside the bunkers, whereas by the present method 80 men would be needed, a difference which requires no emphasizing. Another feature is that the men employed on a Suisted elevator are all under cover, which does away with the necessity of stopping work when it is raining, thereby effecting a considerable saving both in time and in wages, and adding materially to the comfort and wellfare of the workmen.

Fireless Locomotives

Using Superheated Water in Place of a Coal Fire

FIRELESS locomotives of various types have been invented but only the simplest one, the Lamm-Francq hot water locomotive has demonstrated its practical value. The invention, in its original form, comes from America where in 1872 the dentist Emil Lamm patented the idea of employing superheated water as a reservoir of heat and a source of steam for the operation of a small locomotive engine. Machines of this type were used on street railways in New Orleans in 1873, but they did not work economically.

In these locomotives the boiler or container was simply filled with water heatea to 400 deg. Fahr. In 1875 the French engineer Francq introducea an improvement by filling the boiler with cold water and injecting steam until the temperature was raised to 400 deg. Fahr., and the pressure to 15 atmospheres.

This principle is employed in the fireless locomotives of to-day, which may be regarded as accumulator engines, deriving their power from water heated under pressure far above its boiling point. The following description of the construction and operation of these machines is condensed from *Die Welt der Technik*.

Fig. 1 shows a railway shunting engine of German make. The cylinders, which are placed at the rear end, under the cab, are unusually large in order that they may work efficiently at low pressure. The tubeless boiler, of cylindrical form with vaulted ends, is also made very large and strong in order to contain a considerable store of energy. It has one or more partial partitions, rising above water level, to check oscillations caused by sudden shocks in the great mass of water. The boiler is provided with an inlet for the admission of steam generated in a stationary boiler.

These locomotives can draw loads until the steam pressure has fallen to 2 atmospheres and can then run several hundred yards before the pressure sinks to 1 atmosphere, at which point a fresh injection of steam becomes necessary. Two fillings usually suffice for a day's service, but the number, of course, varies with the work.

In order to expedite the charging and to mix the steam and water intimately, the boiler often has an internal

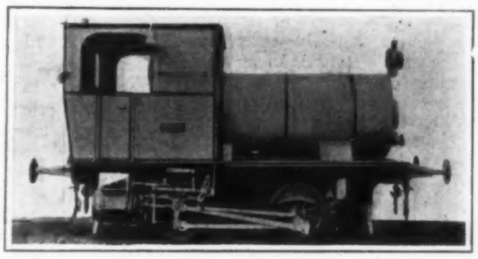


Fig. 1—A Type of Fireless Locomotive Which is Used for Shunting in Germany.

steam pipe connected with the inlet. This pipe lies lengthwise along the bottom of the boiler, increases in diameter in proportion to the distance from the inlet, and is perforated along the lower side. Easily removable guard plates are placed beneath the pipe to prevent the boiler plates from being injured by the eddy-forming action of the inrushing jets of steam.

The loss of heat by radiation is reduced to a minimum by covering the boiler with two sheet-iron jackets, between which is placed a layer of felt, 1.2 inches thick, while an air space of the same thickness separates the inner jacket from the boiler. In some cases a combination of mica and asbestos is employed instead of the ordinary boiler felt. When the locomotive stands idle in the open air in normal weather conditions the loss of pressure by radiation is only ¼ to ⅓ atmosphere per hour. If a locomotive having 5 atmospheres pressure at the end of the day's work is placed in a closed shed it loses less than 2 atmospheres during the night and in the morning is ready to begin work with a pressure of 3 atmospheres. The cylinders are protected against loss of heat by a layer of felt covered by a sheet-iron jacket.

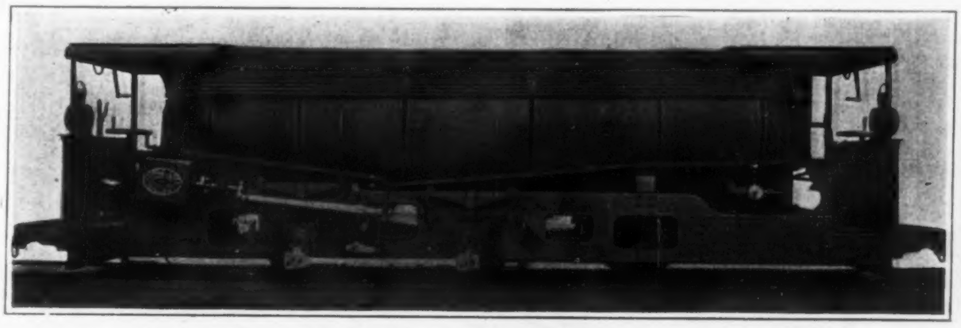


Fig. 2—A Narrow Gage Fireless Locomotive Employed in a German Mine.

In the course of its service the fireless locomotive creates for itself an additional protection against radiation in the scale deposited from the water on the inside of the boiler.

In ordinary locomotives the prompt removal of this deposit is very important and essential to the maintenance of high efficiency, but in fireless locomotives the boiler scale is not removed, as it is a good heat insulator.

The water level must be kept near a certain normal value in order to make the operation economical. If the water is too high the steam which passes into the cylinder may become too wet, while if it is too low the capacity of the boiler is not fully utilized. Usually the height of water in the boiler remains nearly constant, as the water lost in the form of steam during working hours is automatically replaced by condensation of the fresh steam injected in the recharging operation. Experience has shown that the best results are obtained when three-fourths of the capacity of the boiler are occupied by water, and one-fourth by steam.

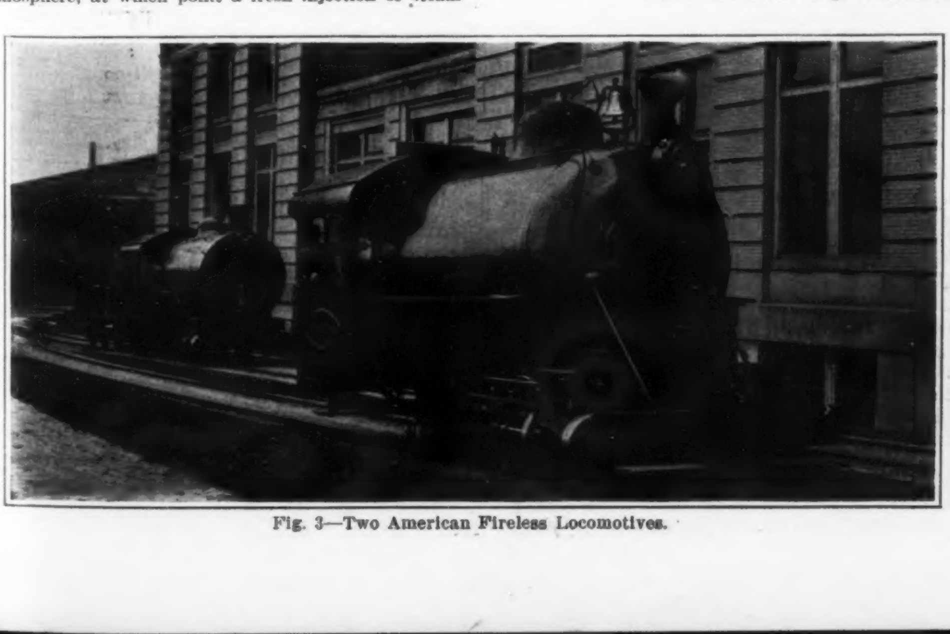


Fig. 3—Two American Fireless Locomotives.

The dimensions of a fireless locomotive must be calculated with greater nicety than those of an ordinary locomotive. In the case of the latter the chief points to be considered are the greatest load, grade and speed at which the locomotive is designed to work, but in the case of the fireless locomotive it is necessary to consider also the length of time during which the machine can work without recharging. If a fireless locomotive is required to draw a train over a considerable distance it is essential to know that it will not become stalled on the way for want of steam. Neglect of these important considerations in the past has caused many failures and brought much undeserved discredit upon this very economical engine of transportation.

The boiler of the fireless locomotive must always be large enough to store an amount of energy considerably in excess of the normal or average demand. This is especially necessary in locomotives designed for regular railway service, where a snowstorm or even a strong head wind may call for an abnormal expenditure of power.

Fireless locomotives can be employed with advantage in many cases where the service required is too light for the economical use of ordinary locomotives, especially for moving loaded cars, small or large, in industrial establishments, and over the short spurs which connect them with railway lines. In many industries, and above all in gunpowder and nitroglycerine factories, the fireless locomotive has proved to be the only allowable means of conveyance, as it emits neither sparks nor smoke or gas. For the same reason it is well suited for use in mines and tunnels. The fireless locomotive can be employed most advantageously on tracks which have no very steep grades. A stationary boiler plant is usually required for charging the fireless locomotive but in some cases it is practicable to charge it with steam from a locomotive of the ordinary type.

The peculiar advantages of the fireless locomotive are that it is (when charged) ready to start at any instant, it does not require an experienced engineer but can be operated by any good workman, it needs no stoker, can be left under steam without attendance, and can be charged in 15 minutes. (Nearly two hours are required to "get up steam" in an ordinary locomotive.)

Fireless locomotives of the type illustrated in Fig. 1 are extensively used in shunting on standard gage tracks. The boiler contains about 105 cubic feet of water and 35 cubic feet of steam. About 770 pounds of steam at a pressure of 12 atmospheres are required to raise the pressure in recharging, from 2 to 11 atmospheres. With this charge the locomotive is able to draw itself and a gross load of 100 tons about 6 miles on a level track, the pressure falling meanwhile from 11 to 2 atmospheres. All moving parts are exposed so that they can easily be cleaned and lubricated. The wheel base is about 6 feet. Fireless locomotives of very narrow gage are also constructed. One of 28 inches gage, designed especially for use in a mine, is shown in Fig. 2. The gallery in which the locomotive is used is nearly 3 miles long and it rises 230 feet, with a maximum grade of 2 per cent, in going from the workings to the foot of the shaft. The locomotive makes the round trip of 6 miles with one charge and an initial pressure of 12 atmospheres, drawing a load of 25 tons at a speed of about 7.5 miles per hour. The height of the locomotive was limited to 77 inches and its greatest width to 53 inches by the dimensions of the gallery. Even with a gage of only 28 inches, therefore, it was necessary to place the cylinders, of 16 inches diameter and 12½ inches stroke, inside the frame of the machine.

As the locomotive is designed to travel in either direction it has a completely equipped driver's platform at each end. The fully charged locomotive weighs 15 tons. It has four driving wheels of 25½ inches diameter and two bearing wheels of 19½ inches diameter. The rigid wheel base is 55 inches, the total wheel base is 110 inches. The locomotive can negotiate curves of 50 feet radius.

In order to prevent the view of the driver being obscured by clouds of steam, the exhaust steam is conducted into small pipes placed over the boiler, as shown in Fig. 2. In these pipes most of the steam is condensed by radiation. The mixed steam and water pass from the pipes into a vessel in which they separate, the small volume of uncondensed steam escaping silently and almost invisibly into the air, and the water flowing off through an overflow pipe.

Cranes and other hoisting machinery can be operated very economically with fireless locomotives.

In most cases fireless locomotives obtain their steam from a fixed plant which existed before their introduction, but in a Norwegian iron mining establishment a boiler plant has been installed expressly for the supply of fireless locomotives. In this case it was deemed inexpedient to install an electric railway because the overhead conductor would be greatly exposed to damage caused by blasting, and because frequently shifting of the conductor, as well as the rails, would be necessary. The company operates six mines, the shafts of which are from 2,300 to 7,550 feet distant from the common smelting furnaces. The mines are connected by railway tracks with the furnaces and with each other. The mouths of the shafts, with one exception, are higher than the furnaces so that only empty cars need be hauled up the rather steep grades, which have a maximum slope of 3.6 per cent. Two locomotives are coupled together for hauling trains of loaded cars from the one shaft which is lower than the furnaces.

Eight fireless locomotives are now in service. Each weighs about 22 tons when empty and 33 tons when charged. The capacity of the boiler is 460 cubic feet, the maximum steam pressure 14 atmospheres. The cylinders are of 21½ inches diameter and 19½ inches stroke. The diameter of the wheels is 40 inches and the length of the wheel base 110 inches.

The stationary boiler plant is so situated that it can be easily reached from every mine. Five locomotives can be charged simultaneously. Despite the cost of the special boiler plant, the fireless locomotives have proved to be an economical means of transportation in this instance also.

The economy of fireless locomotives in general, in comparison with ordinary locomotives and with horses, is illustrated in the German article by examples and calculations which need not be reproduced in detail, as they are based upon German prices. It is shown that the cost of four hours' daily service in shunting railway cars is 60 per cent greater with an ordinary locomotive and 76 per cent greater with horses than it is when a fireless locomotive is employed. The advantage of the fireless locomotive, in this computation, is due largely to its great saving in wages and in charges for maintenance, repair, and amortization.

In comparison with gasoline and electric motors the fireless locomotives present the advantages of extreme simplicity, absence of such delicate parts as spark plugs and accumulators, and independence of fixed conductors.

Two fireless locomotives, said to be the only ones in the United States, are shown in Fig. 3. They were built at Lima, Ohio, and are used for shunting cars in a large factory at Dayton. The boiler is 13 feet long, 6 feet in diameter and has a capacity of 346 cubic feet. It is half filled with water, and steam at 150 pounds pressure is injected for 12 or 15 minutes, raising the internal pressure to 150 pounds and increasing the water content, by condensation, to three-quarters the capacity of the boiler. The steam is admitted to the cylinders, through a reducing valve, at a maximum pressure of 60 pounds. The locomotive will work with a 10 pounds pressure and loses only 3 or 4 pounds per hour by radiation. When fully charged it weighs about 75,000 pounds and is capable of working from two to three hours, according to the number and weight of cars hauled.

Some Facts About Malaria

Its Cause and Mode of Propagation

Malaria is not a difficult disease to fight. This has been shown in many parts of the world—in Italy, in Cuba, in Panama, in West Africa, in India, in Egypt, and elsewhere. People generally should know the exact truth about the disease and what is to be done. The efforts of individuals, after they have acquired the proper knowledge, will have an effect upon the malaria rate, while with a general knowledge of these facts community work must come sooner or later.

In the following, taken from Dr. L. C. Howard's bulletin published by the U. S. Department of Agriculture, the statements regarding the disease itself are partly drawn from an admirable summary prepared by Sir Ronald Ross, of the Liverpool School of Tropical Medicine, who was the first discoverer of the relation between malaria and mosquitoes, something over twelve years ago, in India. His results were soon confirmed by workers in many parts of the world, and the statements here made are accepted by the best physicians of all countries.

THE DISEASE AND ITS CAUSE.

The disease known as malaria, or fever and ague, or chills and fever, or marsh fever, and the varieties called intermittent fever, remittent fever and pernicious fever, are caused by parasites in the blood which feed upon the red blood cells.

Malaria occurs more or less in all warm climates, especially in the summer after the rains and near marshy ground. It is said to cause one-fourth or more of all the sickness in the Tropics.

The parasites in the blood are microscopic one-celled animals called plasmodia.

These minute parasites are introduced into the blood through the proboscis of certain mosquitoes of the genus Anopheles.

On being introduced in this way, each parasite enters one of the red blood cells, in which it lives and grows.

When full grown, each parasite divides and thus produces a number of spores, which escape from the blood cell and enter fresh cells. This method of propagation may continue for years.

Although only a few of the parasites may have been introduced originally through the beak of the mosquito, they rapidly increase until millions upon millions of them may exist in the blood.

At first, when the number of parasites is still small, an infected person may remain apparently well. When, however, the number is large enough, he begins to suffer from fever.

The parasites tend to produce their spores all at the same time, and it is at the moment when these spores escape from the blood cells, almost simultaneously, that the fever begins.

The fever is probably caused by a little poison which escapes from each parasite with the spores.

After from 6 to 40 hours or more this poison is eliminated from the patient's system and his fever tends to leave him.

In the meantime, however, a new generation of parasites from the spores is approaching maturity; and when this is reached they in their turn break up and cause another attack of the fever like the first, and so on indefinitely for months and months. In this way the attacks of the fever follow each other at regular intervals.

But it often happens, as the result of repeated infections, that a new attack has commenced before the former one has ceased, so that they overlap and the fever continues.

After a time, even without treatment, the number of parasites may decrease until not enough of them are left to produce fever, in which case the patient improves temporarily.

It generally happens, however, sooner or later, that the number of parasites increases again, and the patient again suffers from a series of attacks.

Such relapses are frequently encouraged by fatigue heat, chill, wetting, dissipation, or illness, and they may occur at intervals for a long time after the patient was first infected by the mosquito, and even after he has removed to localities where there is no malaria.

Besides fever, these malarial parasites often produce anemia and enlargement of the spleen, especially with patients who have suffered many relapses.

Death is often caused in malarial patients by other diseases, such as pneumonia or dysentery, the system being already weakened by the malarial parasites.

If the patient survives, the parasites tend to die out of themselves, without treatment, after a long period of illness, leaving him more or less immune.

The parasites are of at least three kinds, which can be easily distinguished in the blood if placed under the microscope. These are (1) a parasite which produces its spores every three days and causes what is called quartan fever; (2) a parasite which produces its spores every other day and causes tertian fever; (3) parasites which cause the so-called malignant fever or pernicious malaria, which is of an irregular type and in which dangerous complications most frequently occur.

Quinine kills the parasites when administered at the proper time; but generally it will not destroy all the parasites in the body unless it is given in sufficient doses and continued for several months. As long as a single parasite remains alive in the blood, the patient may be subject to relapses. Ross advises that at least 5 grains of sulphate of quinine should be taken by an adult patient every day without fail for four months, but he should consult a physician regarding the details of the treatment.

METHOD OF INFECTION.

The malaria parasite has several different stages. Aside from those forms which produce spores in the body, there are other stages—male and female. When one of these anopheline mosquitoes, which carries malaria, happens to feed on a patient whose blood contains parasites, these are sucked, with the blood, into the mosquito's stomach.

If the sexual forms of the parasites are present, those of opposite sexes at once unite. The parasite now undergoes certain changes in the mosquito's stomach. It passes through the stomach wall and finally affixes itself to its outer surface.

Here it grows very considerably, and, after a week under favorable conditions, produces a large number of spores.

These spores, thus entering the general body cavity of the mosquito, find their way into the salivary glands. These glands secrete the irritating fluid injected under the human skin when the mosquito begins to feed.

Thus, when one of these mosquitoes, which has fed upon a malarial patient containing the sexual forms of the parasites, bites, after a week, another person, it injects these spores together with its saliva under his skin and generally into his blood.

These spores now cause or may cause infection or reinfection in this second person.

Thus the parasites of malaria pass from men to certain mosquitoes and back from these mosquitoes to men.

Malarial fever is then an infectious disease, which is carried from the sick to the healthy by anopheline mosquitoes, and only in this way can it be contracted.

It has always been known that malaria is most prevalent in the vicinity of marshes, and it was formerly supposed that the air or exhalations from these marshes produced the disease. Parasites of malaria have not been found in the water or air of marshes, nor in decaying vegetation, nor in the soil, although they have been diligently searched for. Attempts to produce infection by these agencies have always failed. The mosquitoes which carry these parasites, however, breed in marshes or in marshy pools and streams.

Issuing from these breeding places, they enter nearby houses and feed upon the inmates, mostly at night, biting first one person and then others, and living for weeks or months.

If an infected person happens to be present in any of these houses, the anopheline mosquitoes biting him will also become infected, and the disease is likely, ultimately, to be carried by these mosquitoes to others and to neighboring houses.

Thus a whole neighborhood soon becomes infected and the locality is called malarious. In such localities it is easy to find the parasites of malaria in the proper mosquitoes. Sometimes 25 per cent or more of them are found to be infected.

In malarious localities the anopheline mosquitoes bite the healthy new-born children and infect many of them.

Such children if not thoroughly treated may remain infected for years. They may become anemic and possess enlarged spleens, and of course may spread the infection to others.

In malarious localities almost every child has been found to contain the parasites of malaria or to possess an enlarged spleen.

In such a locality, therefore, the infection is constantly passed on by means of the mosquitoes from the older children or from adults to the newly born infants, so that the locality may remain malarious for very many years, in fact indefinitely.

In the same way a newcomer arriving in such a locality will very probably become infected, especially if he sleeps in an infected house, even for one night, at a time when mosquitoes are flying and biting. A locality is malarious only when it contains persons infected with the parasites, and also sufficient numbers of the proper species of mosquitoes to carry the infection to the healthy persons.

Return Flight of Carrier Pigeons

Novel Theory Advanced—Hints for Aviators

By M. Tevis

One of the most absorbingly interesting fields of investigation in that realm of "Nature Study" (which has had such an amazing growth in popular esteem during the past few years) is the comparatively new science of animal psychology.

Dr. Hornaday, the distinguished naturalist at the head of the Bronx Zoological Gardens, at New York, recently remarked to the writer that a considerable number of American scientists, including himself, have of late been devoting special attention to this subject.

In France the observations and experiments of investigators along this line have for several years been co-ordinated under the auspices of the "Institute of Animal Psychology."

One of the most fascinating problems which has engaged the attention of this body of savants is that of the "homing instinct" of the carrier-pigeon. The results of a long series of careful observations and scientifically conducted experimental tests have just been made public by the well-known director of the Institute, M. Hachet-Souplet.

The conclusions to which he declares himself forced by weight of evidence as well as plausibility of theory are very remarkable, but most convincingly presented.

The reason for the return of the bird is essentially psychological, he declares, and consists in an association of ideas which gives rise to an irresistible impulse, whose threefold cord is woven of the strands of the desire for food, for shelter, and for the "sexual complement," which form indeed the most powerful motives of action of all sentient creatures. Note, however, that these desires are not directly operative stimuli, but factors of a psychological impression or habit of mind. This is very neatly demonstrated by the fact that a plentiful supply of food or shelter as good as that to which the bird is accustomed will not prevent the operation of the homing instinct. In this connection M. Hachet-Souplet somewhat subtly observes that, though the more immediate stimulus is in itself stronger, the bird is more sensitive to the psychological stumulus, which is of course reinforced by the power of habit.

But granting this, how is the bird able to respond to this imperative call of nature exerted over so great a distance? The answer is even more startling. M. Hachet-Souplet does not hesitate to affirm that the return flight is ordinarily directed by sight alone, and this affirmation is supported not only by a destructive criticism of previous theories but also by a carefully constructed theory based on scientific experiment and unbiased observation of fact.

This view is pregnant with interest, in the opinion of the present writer, not merely to the pigeon-fancier and the scientific man, but to the practical aviator as well.

For untold centuries men have been studying the flight of birds and the structure of their wings and bodies, lured by the dazzling dream, so recently become a reality, of rivaling them in the yet unconquered realm of the air. There are still extant some marvelous anatomical studies of the pinions of birds made by Da Vinci, of the master-mind and the cunning hand, in his efforts to solve this problem. And doubtless Icarus and Daedalus, or their prototypes, tried their hand at similar sketches! But no one has thought of studying the eye of the bird as an aid to flight. Yet herein may lie aid for the aeroplanist in the achievement of that task of returning to a given starting point, which is of such vast importance if the flying-machine is to be of practical use either in peace or in war.

That the eye is a sole or chief means of guidance in the homing of carrier pigeons has hitherto been regarded as untenable because of the great distances covered by the birds—several hundred miles in well-attested instances. Consequently a number of highly ingenious theories or surmises have been advanced from time to time as an explanation for so remarkable a feat.

Some of these and the manner of their refutation are worth considering briefly.

In the first place there was the idea of some mysterious special sense.

Thus one group of enthusiasts held that the pigeon was somehow guided by magneto-electric currents. Now while all living creatures are more or less affected by electrical conditions and disturbances of the atmosphere, and birds are perhaps particularly so, there is no evidence whatever to show that the pigeon possesses any sort of "natural compass" as a guide.

Then M. Bonnier, the eminent authority upon the ear, wrote a highly ingenious treatise to prove that the semi-circular canals of the inner ear registered certain disturbances which enabled the bird to find its way back along the route taken.

Since physiologists generally hold that the semicircular canals are organs of balance and direction, this view held sufficient plausibility for the members of the Institute to consider it seriously. It was easily disproved by two simple experiments. In the first place the birds found their way back even when the canals had been injured or destroyed. Secondly, when a movable pigeon-house was used and transferred to a distance of several kilometers while the birds were left at the starting point, they found it without trouble, though obviously the movements of the house could not have caused disturbances in their ears!

The opinion that the return flight was merely a mechanical reversal of the original journey is likewise negatived by the above experiment, as also by the fact that no matter how tortuous the original trip, the return is always made in a bee-line.

Lastly, the idea of a sort of mental topographical record made by observation of marked features of the landscape is contravened by the fact that birds carried in covered baskets found their way home when the distance was not too great. But of this we shall speak further on.

Taking up direct proof that vision is the chief factor involved in this supposedly "mysterious instinct," we find a very strong argument in the fact that *blinded pigeons are always incapable of finding their way home*. Furthermore, when released in a snow storm, even at comparatively short distances, the bird seemed always confused, and found it difficult or impossible to return, doubtless because the familiar aspect of things was altered.

But it must be observed that untrained birds are not successful "homers." M. Hachet-Souplet even asserts that birds raised in an aviary and never allowed to leave it, and then taken out for even so short a distance as five or six miles, will be unable to find their way back, and in fact will be lost in ninety-nine cases out of a hundred.

In short, they must be trained by a series of flights, beginning at very short distances and gradually increasing in length.

Within a limited zone it is obvious that the triple attraction of food, mate, and shelter exert a direct influence through vision. Obviously, too, this zone is gradually enlarged as sight is trained, but how account for the extension of its limits to hundreds of miles? This is the crux of the matter and M. Hachet-Souplet answers the criticisms of objectors by an appeal to certain laws of optics which have heretofore been disregarded as possible factors.

In the first place, it has been proved by the observations and records made by the scientist, Dr. Soubies, in his balloon ascensions, that keenness of vision increases very markedly with increase of altitude for human beings. The entomologist Forel finds reason to believe that the same thing is true of insects, and it is highly probable that birds have a similar hyperacuity of sight at great heights.

But it is a well-established fact that the farther from home pigeons are, the higher they soar before starting on the homeward journey.

A second point of great importance is that at great heights a much wider range of vision is possible than has generally been supposed or than the laws of triangulation would seem to allow, owing to the fact that there is an apparent lifting of the horizon due to the refraction of light when passing through the various layers of air of different density lying between the surface of the earth and very high altitudes. It is because of this law that the bowl of a spoon standing in a glass half-full of water seems to be on a higher level than it really is. And to this law, together with that of perspective, is due the curious phenomenon observed by balloonists that as they leave the earth behind it seems to assume the shape of a basin with the horizon apparently on a level with the car.*

From these two laws of optics it is clear that direct vision is of greater extent than has been supposed, but even more significant is the consideration that such vision is not required for the production of the requisite stimulus to return. All that is necessary is the rousing of a *sensation* of the *familiar* and the *desired*, and through association of ideas and the force of habit, sensation may be roused without the perception of definite images, but merely through an impression of a familiar neighborhood. And here we see the part played by training. Successive liberations at increasingly greater distances give the bird a series of visual impressions in connection with the nest and its surroundings. It should be observed also as a psychological element that if distance diminishes intensity of sensation, it probably augments intensity of desire.

As concerns return flights of a length greater than can be accounted for by the above considerations, M. Hachet-Souplet observes that they are few in number and very ill-attested by competent witnesses. The subject indeed is one that until recently has attracted the sentimentalist more than the scientist, and sentimentalists are notoriously inaccurate observers. Doubtless some such returns have been due to chance, and some to following other birds until a familiar zone was reached.

In view of the facts above presented it would seem that a powerful telescope or pair of binoculars might be of very efficient service to the cross-country aviator who wished to return as rapidly as possible to his starting point. Also that ascending to high altitudes would help him to get his bearings quickly, and finally

*See our article "Why the Earth Appears Concave," Scientific American Supplement, October 7th, 1911; p. 227.

that when engaged in such service as naval or military scouting, a series of practice flights of gradually increasing radius would be of invaluable service in training the eye, reducing the aviator's dependence on chart and compass.

Mr. Leo Stevens, one of the most experienced balloonists and "air men" in America, with whom the writer recently discussed the subject in hand, warmly approved the idea above advocated of eye-training for aviators.

Mr. Stevens has frequently liberated carrier-pigeons from balloons at heights varying from 7,000 to 14,000 feet and has furnished some interesting data as to the behavior of the birds. Some of his data seem, moreover, to bear out the theories of M. Hachet-Souplet.

He has been able to obtain successful homing flights at distances of over 200 miles and at altitudes even as high as 14,000 feet. Occasionally, however, birds have been picked up dead below the point of liberation, their frozen bodies offering mute testimony of the intense cold frequently prevailing at lofty heights. All birds liberated suddenly in very rare atmospheres of course fall like stones for a certain distance before they gain control of their wings, and probably these poor little victims of experiment encountered intense and paralyzing cold before they began to fly.

The speed attained in the homing flight in some cases averaged over a mile a minute.

But perhaps the most interesting fact noted by Mr. Stevens was that when freed at great heights or distances the birds have a canny trick of flying to the top of the balloon and riding awhile until they have gained their bearings. Hachet-Souplet would doubtless regard this circumstance as strongly confirmatory of his contentions.

Sometimes, moreover, where several pigeons were carried for the purpose of obtaining records from varying heights and distances, the first one freed would ride atop the gas bag until a companion was let loose, when the two would fly off together. This too seems to support the French scientist's theory of the bird's propensity to follow a leader or seek companionship when very far afield, or outside the zone of general familiarity.

The whole topic is one of great interest from various points of view, and whether or not the opinions of this eminent student of animal psychology be accepted as conclusive, he has certainly made a very stimulating contribution to the solution of one of the most fascinating questions of zoological science.

Insect Aviation

Nature as an Aeronautical Engineer

Great advances have recently been made in the speed of aeroplanes and the power of their motors but in point of safety the apparatus is still very defective. Accidents, nearly always of the same type, occur almost daily.

On June 11th, at Johannisthal, for example, Schendel attempted to descend by soaring. Suddenly his monoplane assumed a nearly vertical position. He righted it but it pitched again, dived straight downward and dashed the aviator to death. This is the almost universal type of accident. Derangements of the propeller are rare and explosions occur very seldom.

Now, no flying animal ever capsizes. Hence, there must be some radical defect in the present construction of aeroplanes. This defect is the lack of the automatic stability possessed by all flying animals.

All practical aeroplanes are modeled after the monoplane which Langley launched into the air on Lake Michigan in 1897, or after the biplane developed by the Wrights. The success of these types caused Tatin, Ader, Marey, and other able French experimenters to abandon their vain efforts to imitate the flight of birds, the most difficult and impracticable model that could have been selected.

The flight of flies and similar insects closely resembles the flight of an aeroplane. These insects are known as *Diptera* because they possess only two wings, but the second pair of wings with which most insects are provided, is represented in the *Diptera* by a pair of rudimentary organs, known as balancers, each of which consists of a short stiff rod ending in a knob (*b b*, Fig. 1).

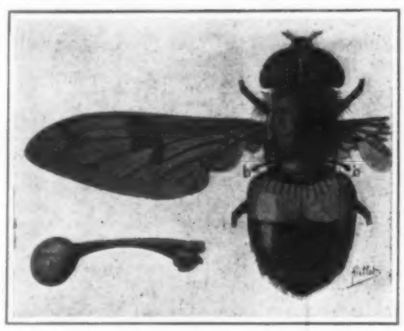


Fig. 1—Volucella Fly Magnified, Showing Balancers *bb*. One of the Balancers is Shown Detached on a Greatly Magnified Scale.

From many experiments, which were made and published long before any practical application of them appeared likely, Dr. Jousset de Bellesme discovered that *Diptera* deprived of their balancers are unable to control their flight and invariably fall. Some of these experiments are described by Dr. de Bellisme in a recent contribution to *La Nature*, which is here summarized.

The balancers of a *Volucella* (a fly which in its larval stage lives as a parasite in wasps' nests) were amputated and the insect was placed on the edge of a table. It attempted to fly but described the parabolic course indicated in Fig. 8, struck the floor with its head and fell over on its back, with its head toward the table and about a yard away from it. Recovering from the shock the insect scrambled to its feet, crawled a short distance and again attempted flight, under much more unfavorable conditions than before, when it had started from an elevated point. By a vigorous effort of its legs and wings it sprang upward a few inches then again descended in a parabolic course, struck the floor violently with its head and fell over on its back, about four inches from its starting point (Fig. 2). After a few failures of this sort the insect resigned itself to crawling except

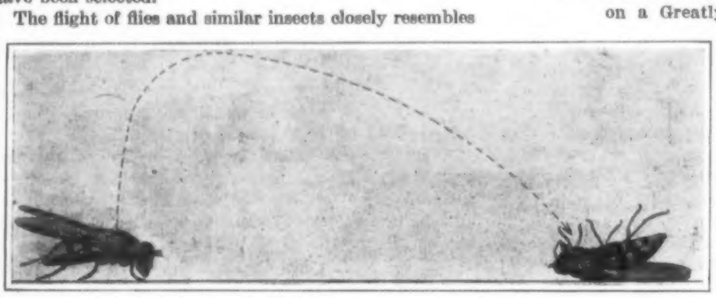


Fig. 2—A Volucella Without Balancers Attempts to Rise from the Ground, but Immediately Falls.

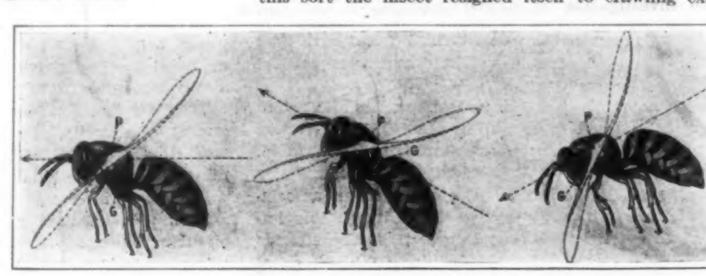


Fig. 3—Relative Positions of Axis of Support (*P*) and Center of Gravity (*G*) in a Wasp.

Fig. 4—Relative Positions of Axis of Support (Dotted Line) and Center of Gravity (Black Dot) in Horizontal Plan of a Fly. The Direction of Flight is Horizontal in (1), Ascending in (2), Descending in (3).

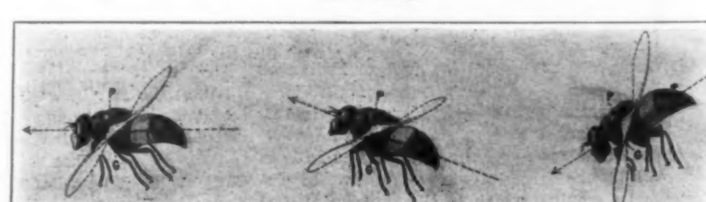


Fig. 5—Relative Positions of Axis of Support (*P*) and Center of Gravity (*G*) in Profile Views of a Fly in Horizontal, Ascending and Descending Flight.

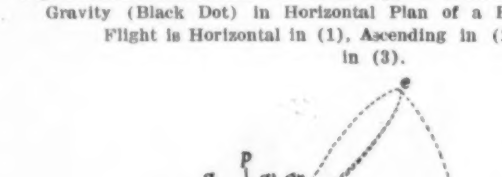


Fig. 6—Profile View of Wasp. *p*, Fixed Axis of Support; *d c*, Constant Amplitude of Wing Beat; *a a' a"*, Positions of Tip of Abdomen in Descending; Horizontal and Ascending Flight; *g g' g"*, Corresponding Positions of Center of Gravity.

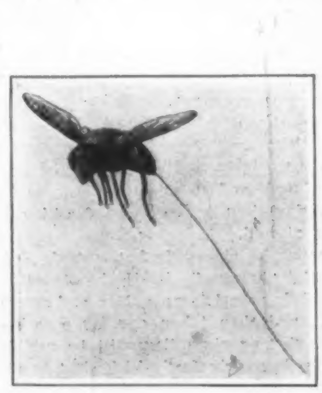


Fig. 7—Volucella Deprived of Balancers, But Enabled to Fly by Loading Its Abdomen With a Horse Hair.

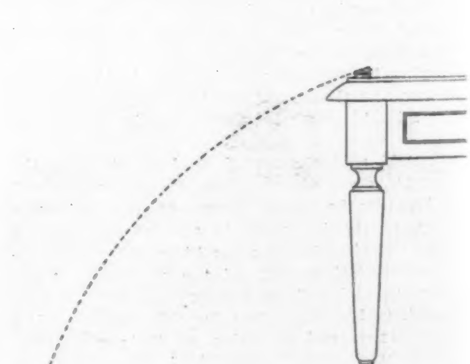


Fig. 8—A Volucella Deprived of Its Balancers Falls in a Parabolic Curve.

when an attempt to seize it was made, when it again attempted to fly, but invariably with the same result. It had become incapable of horizontal or ascending flight. In reading this description it is impossible to avoid thinking of the typical aeroplane wreck.

In order to learn why the fly's stability is destroyed by removing its tiny balancers it is necessary to study the conditions of flight in an insect of this type. The insect may be considered to be supported by an axis which intersects the wings in two points, called centers of action (*p* in Figs. 3, 4, 5, and 6). The axis of the body turns about this axis of support, and the direction of the axis of the body and the line of flight is determined by the relative positions of the axis of support (*p*) and the center of gravity (*g*).

In flying insects the center of gravity is situated in the lower and posterior part of the thorax. It is nearly stationary in *Diptera*, in which the abdomen is closely attached to the thorax, but in *Hymenoptera* (bees, wasps, etc.) the abdomen is separated from the thorax by a narrow and flexible waist (Fig. 6), is very mobile, so that the center of gravity can move forward and backward to a considerable extent.

Now, in order to assure stability in flight it is necessary to provide some means of keeping the center of gravity directly below the axis of support, or of bringing it back to this position quickly after any accidental displacement. This result is accomplished by different methods in *Diptera* and *Hymenoptera*. In *Diptera* the center of gravity is fixed, but the axis of support is moved forward and backward by the action of the balancers. In *Hymenoptera*, on the contrary, the center of gravity is shifted by flexing the abdomen and the legs, while the axis of support is fixed in the body and the amplitude of vibration of the wings remains constant.

The experiments with *Diptera* have shown that the balancers act as a brake on the wings and limit their backward motion, more or less. If the balancers are thus employed while the insect is flying horizontally, the immediate effect is to move the axis of support forward. The weight of the body then causes it to turn round the axis of support until the center of gravity is again directly under that axis. In this way the axis of the body is inclined and the flight becomes obliquely ascending (Figs. 4 and 5, second diagrams). When the balancers are not used, the backward motion of the wings attains its maximum, the axis of support moves behind the center of gravity, the axis of the body dips in front and the flight becomes obliquely descending (Figs. 4 and 5, third diagrams). In every case the center of gravity remains directly under the axis of support so long as the direction of flight is constant, and any displacement is instantly corrected.

The same conditions of stability are maintained, in one way or another, by all flying insects. In *Hymenoptera*, for example, the extent of the alar vibration is constant and the axis of support is fixed, while the center of gravity is moved forward for descent and backward for ascent by bending and straightening the abdomen (Figs. 3 and 6). This theory was confirmed by experiments in which the power of horizontal and ascending flight, of which *Diptera* had been deprived by the excision of their balancers, was restored by attaching weights to the abdomen. It was found impossible to use wax for this purpose, as its bulk interfered with the movement of the wings. Satisfactory results were obtained by attaching by means of a quickly drying glue a stout straight horse hair, about four inches long, to the extremity of the abdomen, as shown in Fig. 7. The proper length for the hair was determined by trial. When the hair was too long the insect's attempt to fly resulted in a fall in which the abdomen first touched the floor. The hair was gradually shortened until the insect made a slightly ascending flight to the window curtain. An additional and very minute shortening resulted in a perfectly horizontal flight.

These experiments and the theory of stability deduced from them show clearly why aeroplanes, as they are now constructed, are so liable to shipwreck by diving. The center of gravity is not far enough below the axis of support and the aviator does not possess the insect's power of shifting the center of gravity quickly in order to correct any displacement caused, for example, by a sudden gust acting on the long tail of the aeroplane.

Without entering into details of construction it is possible to conceive a flying machine driven by two propellers, attached laterally in such positions that the axis of support is much higher than the center of gravity, the position of which is determined chiefly by the motor and the body of the aviator. The center of gravity could be moved forward and backward by means of a sliding weight, to a sufficient extent for descent and ascent, the sustaining planes remaining fixed at a small constant inclination to the axis of the machine.

There are certainly interesting studies to be made in this direction and constructors would do well to seek safety rather than excessive speed. It is questionable whether the conquest of the air is worth the human sacrifices that are continually offered to it.

A Great Modern Telescope*

The Sixty-inch Reflector of the Mount Wilson Observatory

By C. A. Chant

ONE might be well acquainted with the appearance of the ordinary refracting telescope, which has contributed so much to the world's pleasure and knowledge, and yet hardly be able to recognize the use of some extraordinary constructions, still called telescopes, which have been brought into existence for the investigation of special problems in astronomy. These have arisen through the union of physics with astronomy, and the resulting development of that great branch of science which for some years bore the name of "The New Astronomy," but which is now known as "Astrophysics." The wonderful growth of this subject has been largely due to two great discoveries: (1) the method of spectrum analysis, and (2) the photographic dry-plate.

In the refracting telescope there is a lens, or a combination of lenses, called the objective, at one end of the tube; and at the other end is another combination known as the eye-piece. Light from the heavenly body passes through the objective, which converges the rays to form an image of the object at the principal focus of the lens, and this image is then observed through the eye-piece, which acts like a simple magnifying lens.

Now a concave mirror converges the light which falls upon it, just as a lens does, and so it is possible to construct a telescope, using a mirror for objective.

* Reprinted from *The Westminster* for August, 1911.

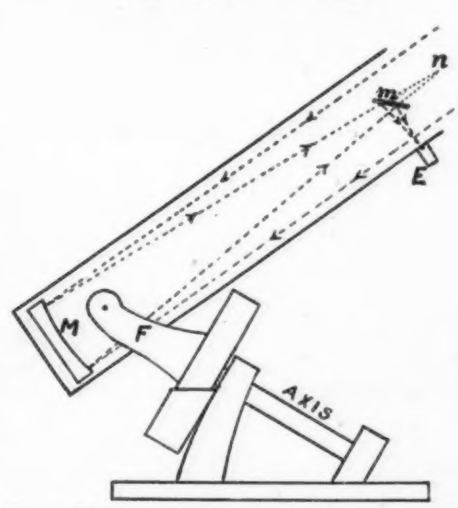


Fig. 1—Diagram Showing the Action of the Reflecting Telescope. *M* is the large concave mirror on Which the Rays Strike. They are Reflected Back to the Small Plane Mirror *m*, and Thence into the Eye-Piece *E*.

Such a telescope is called a reflector, and the manner in which it works is shown in the accompanying diagram. (Fig. 1.)

The large concave mirror *M*, which is the most distinctive part of the instrument, is placed at the lower end of the tube. The light from the heavenly body passes down the tube, as shown by the arrows, and strikes the mirror, which returns the light, directing it toward *n*, where the image of the body would be formed. For convenience, however, a small plane (i. e., flat) mirror *m*, is interposed in the path of the light and this reflects it out to the eye-piece *E*, behind which is the observer's eye. In place of the eye-piece one can substitute a photographic plate.

The reflecting telescope is not by any means a new invention. The great Sir Isaac Newton constructed one about 1670; and it was brought into great prominence by Sir William Herschel a hundred years later, who, failing to find any one competent to undertake the grinding of large mirrors, resolutely set about it himself. He reached a stage of perfection never before approached; and using his own telescopes, the greatest of which was 4 feet 10 inches in diameter and 40 feet long, he made a survey of the sky and thus laid the foundation of our knowledge of the structure of the universe. In 1842, Lord Rosse, of Parsonstown, near Dublin, Ireland, built his famous instrument, which had a mirror six feet in diameter and a tube 54 feet long, the whole weighing fifteen tons. In these instruments the mirror was made of an alloy of copper and tin, which is hard to work but which keeps its polish well. These giant instruments were very powerful; but they were rather difficult to manage, and the refracting telescope gradually increased in size and distinctly took the lead.

Fig. 2—The 60-Inch Reflecting Telescope of the Mt. Wilson Solar Observatory, Near Pasadena, Southern California.

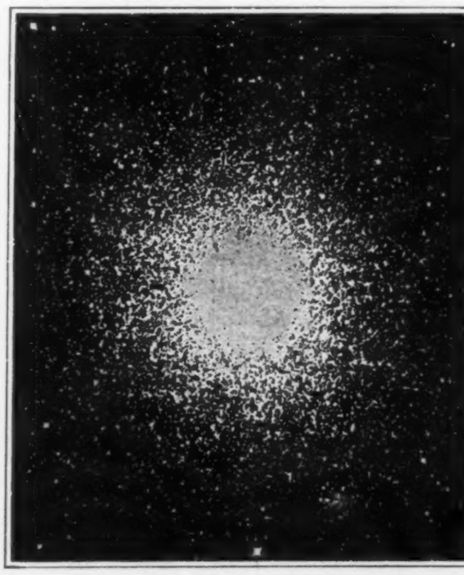


Fig. 3—A Portion of the Great Cluster of Stars in Hercules. The Photograph Showed That There are More Than 25,000 Stars in It. Exposure of Negative, Eleven Hours.

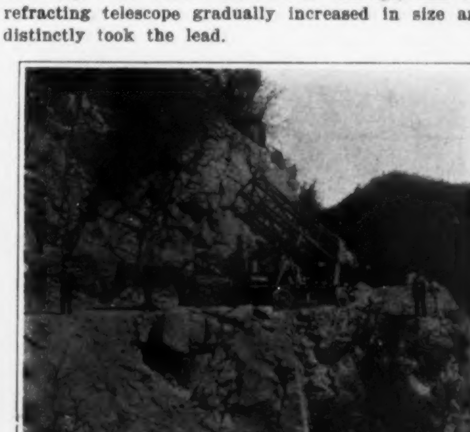


Fig. 4—The Tube of the Great Telescope on Its Way up the Steep and Narrow Mountain Road.

But in recent years it has been demonstrated that for photographing faint objects, such as nebulæ, and star-clusters, and for much work with the spectroscope, the reflector is decidedly superior. This has led to the construction of some notable instruments. The most powerful, as well as the most perfect of these, I shall briefly describe.

It belongs to the Carnegie Solar Observatory and is mounted on the summit of Mount Wilson, near Pasadena, in southern California. A view of it is given in the accompanying engraving. (Fig. 2.)

The mirror is made from a great disk of glass. It is 60 inches in diameter, 7⅝ inches thick at the edge and hollowed out so as to be three-fourths inch thinner at the center. It weighs 1,900 pounds. The coat of silver is deposited, by a chemical process, upon the front surface, not on the rear as in our ordinary mirrors; but the layer is so thin that it contains no more silver than is in a Canadian 5-cent piece. One would think that a glass disk so thick would not change its shape no matter how it was supported, but such is not the case. It has to be held so that the pressure is uniformly distributed over its rear surface. This is accomplished by an elaborate system of levers and weights, seen in the picture at the lower end of the tube. The slightest bending of the glass alter the curvature of the mirror and renders it of less use than a mirror lens of much smaller diameter.

It will be seen that the tube in this case is just an open steel framework. The elaborate mechanism at the side is for pointing the telescope in any desired direction, but the greater part of the controlling mechanism is below the floor and cannot be seen. The telescope is mounted in a fork *F* (Fig. 1), rigidly attached to the end of an axis parallel to the axis of the earth. This axis is a hollow forging of nickel-steel, 15 feet long and varying in diameter from 15 to 18 inches, and an immense driving-clock with a revolving pendulum causes it to rotate once in twenty-four hours. This allows the telescope to follow the stars in their motion across the sky. Now the moving parts of the instrument weigh nearly twenty-three tons, and one would expect that great force would be required to overcome the friction of the bearings. But this friction is almost entirely eliminated by an extremely ingenious arrangement. Upon the axis is a great hollow disk of steel, ten feet in diameter and two feet thick. The upper portion of it is seen in the picture. This disk snugly fits in a trough into which mercury is poured. As a cork is buoyed up by water, so this disk is held up by the mercury, and almost all of the pressure is removed from the bearings. As a result, the clock moves the great mass with ease and wonderful smoothness.

Now the mirror is figured with the utmost accuracy, and a change in temperature alters its form. A rise in temperature also causes expansion in the mountings. Indeed, experiments showed that for highest efficiency there should not be a daily variation in the temperature of the mirror of more than two deg. Fahr. To accomplish this result extraordinary precautions have been taken. The building containing the instrument has two sheet-metal walls, with a space of two feet between them. The dome is further protected from the sun by a white canvas shield two or three feet above it. The whole building is practically air-tight. Still further, during the day the telescope is covered by a "canopy" 15 feet high, 15 feet long and 11 feet wide, made of four thicknesses of fine woolen blankets, quilted between covers of white canvas.

With these precautions, and numerous other refinements which I cannot specify here, results have been attained with this instrument which are far in advance of any heretofore secured. During the summer of 1910 the present writer had the privilege of observing the Great Cluster of Stars in the constellation Hercules, the planet Saturn and the "Trapezium" in the Orion Nebula. The revelation of detail and of delicate coloring was simply exquisite.

Fig. 5—A Glass Disk 100 Inches in Diameter and 12 Inches Thick, on the Machine for Grinding it into a Concave Mirror.

But the photographs of celestial objects obtained with the instrument are even more notable. They exhibit the structure of some of the faint nebulæ and clusters in a manner never before approached. The accompanying picture (Fig. 3) is made from a photograph of a portion of the great Hercules Cluster. This immense aggregation of suns was discovered in 1714 by Halley. In a small telescope it appears as a hazy star, but a large instrument reveals a mass of sparkling points of light. At first it was thought that there might be one or two thousand separate bodies in it, and later this was increased, by actual count of an excellent photograph, to 6,000; but the photographs with the 60-inch reflector reveal as many as 25,000 single stars, all probably connected as a whole and each a sun! Star-clusters are, perhaps, the most difficult of astronomical subjects to photograph. To secure the picture shown, the photographic plate had to be exposed eleven hours, the exposure having been made and finished on three successive nights.

The 60-inch reflector was constructed at Pasadena, in the instrument shop of the Solar Observatory. In design and construction it is entirely the product of Prof. G. W. Ritchey, though in carrying out his plans he had the assistance of several very skilful helpers. Prof. Ritchey has also been the chief observer with his telescope, and the negatives he has obtained are simply unrivalled.

To reach its destination on Mount Wilson, the telescope had to be carried up a steep and narrow road, ten miles in length, cut from the side of the mountain. An accompanying picture (Fig. 4) shows the tube on its way up. It is on a truck of special construction, propelled both by gasoline motors and mules. The length of the tube demanded that it should be movable on its truck, in order to escape overhanging rocks.

The great success obtained with the 60-inch instrument, led Mr. John D. Hooker, a public-spirited citizen of Los Angeles (10 miles from Pasadena), to contribute $50,000 toward the construction of a 100-inch reflector, and this work was placed in Prof. Ritchey's hands. Great difficulty has been experienced in obtaining a disk of glass large enough for the purpose. In our last illustration (Fig. 5) is shown one which was received from France, a foot thick and weighing 4½ tons. On being received its two surfaces were ground flat and parallel, and it was made circular. In the picture this latter operation is shown in progress; the great disk is resting on the grinding table and is being made to rotate while the edge is ground. But the disk was made up of three distinct layers, obtained by pouring three separate meltings one upon the other, and it was feared that it would not be rigid enough to withstand change of figure, and so it was discarded.

A subsequent attempt to cast another disk and to anneal it—indeed it is in the annealing that all the difficulty lies—was unsuccessful; and the makers have practically abandoned the project of supplying a single disk of the required thickness.*

In this predicament Prof. Ritchey has been driven to a new expedient. He proposes to build up a disk, by taking disks 100 inches in diameter and 2 inches thick (which can be obtained quite readily), grinding their surfaces perfectly flat, and then placing one above the other with strips of uniform thickness between them, all cemented together into a whole. Satisfactory mirrors 24 inches in diameter have been made on this plan, and experiments are under way with larger ones, in order to test thoroughly the method before undertaking the monster 100-inch one. So far everything appears promising and it is to be hoped that this invention, truly the child of necessity, will prove entirely successful, so that in a few years the world may be put in possession of a still grander triumph of Prof. Ritchey's ingenuity and skill.

* Late information states that an attempt to use the original disk will be made.—C. A. C.

Insurance Against Unemployment in France

Government Aid for the Man Out-of-Work

Unemployment insurance having attained to the importance of being incorporated in a government measure in Great Britain, it may be interesting to give some account, says *Engineering*, of the attempts which have been made abroad to insure against the risks of unemployment, and their attendant results. For the present it will suffice if we consider the system created for this purpose in France, which although named "insurance," does not properly correspond with what is usually conveyed by that term. Furthermore, insurance against unemployment in France is, in a sense, impracticable, for actuarial tables of unemployment, corresponding with the mortality or accident tables of ordinary insurance, do not exist there.

It is natural that there should be complaint about unemployment in a country so full of syndicates and trade unions as France. Figures, by no means authoritative, are advanced as to the proportion of "out-of-works" in this or that year, or as to the number of unemployed relative to the total population. Such unemployment statistics are, however, of doubtful value, more particularly as workmen who will not accept particular work, or who are on strike, etc., are grouped with those who cannot find work. As a French Socialist Deputy, M. Vaillant, recently stated, a considerable amount of unemployment always prevails, even in times of commercial and industrial prosperity, and the proportion of "out-of-works" often reaches 7, 8, 9, and 10 per cent. According to this authority, at every period of crisis quite a million persons in France may be estimated as unemployed, and the unemployed may always be counted by hundreds of thousands at least. It is true that the French Labor Bureau (Office du Travail) under the Labor Ministry, publish monthly and annual statistics relating to unemployment, but the figures given are, for the most part, furnished by the workmen's syndicates. There is a tendency on the part of the latter to exaggerate the proportion of unemployed; and, in any case, supposing the estimates to be correct, the basis of the figures, relatively to the entire population, is very small, from the fact that the majority of the workers in France are not members of the workmen's syndicates. In the statistics referred to, information emanating from the private or works societies is also utilized; this information is, however, very confused and is of scarcely greater value. The census of population affords some indication of the people who have declared themselves out of work at the time of any particular census; in this way, for example, the figure of 315,000 persons in 1901 was arrived at. In spite of these figures, much alarm was occasioned in France because, according to information supplied by the workers' syndicates, the average of the unemployed was estimated, in 1909, at rather over 8 per cent, while the corresponding mean for 1908 was estimated at 9.6 per cent. It should be mentioned that these latter averages were based upon an aggregate of less than 250,000 individuals, representing the syndicate which furnished particulars to the Labor Bureau. For the year 1910 the percentage of unemployed, taken in the same way, would amount to 6.5 per cent, which, again, concerns a working population very small indeed in comparison with the entire population of France.

Whatever the purely relative worth of these statistics, it is quite certain that unemployment occasionally makes itself painfully felt in some occupations, or at least in the case of certain workers. For this reason various means have been devised in this, as in some other countries, for aiding the unemployed, and at the same time for diminishing unemployment. We are now concerned more especially with that special form of aid which has been denominated "insurance against unemployment;" but, as explained already, in France, in the true sense of the term, this does not exist, although the phrase is used. What is done takes the form of assistance distributed by the workers' syndicates or unions and by special associations, in connection with which there is nothing corresponding to the premiums of an insurance or mutual assurance company, or to the indemnities paid to the victims of accident in the case of accident insurance. In these so-called "insurance" organizations in France, calls are certainly made upon the members, but these contributions are more frequently used for purposes quite other than that of assisting the unemployed. The special feature in connection with these associations and societies is that, on the one hand, the State, and, on the other hand, the towns, departments, and local authorities, aid them by granting subsidies which are considerable in amount when compared with the absolute value of the contributions of the workmen; the sums available for distribution among the unemployed are thus materially augmented.

What is the real value of these so-called insurances against unemployment? The designation has been preserved, notwithstanding that it relates to a system

which has nothing in common with insurance properly so called, as it is the title usually given, even in official documents, to every organization of funds for the benefit of the unemployed (*caisses de secours*) whatever may be their origin. In 1902, on the occasion of an inquiry into the subject by the Labor Minister of that period (M. Millerand), that gentleman dwelt with considerable satisfaction upon what he described as the admirable expansion of insurance against unemployment in France. He congratulated the country on the fact that it had more than 300 insurance funds (*caisses d'assurances*), comprising 36,000 members and receiving over 110,000 francs ($22,000) in contributions. It is easy to show, however, that the 30,000 members and the 110,000 francs are quite insignificant when regard is had to the working population of France. The greater part of the funds above enumerated belong to a single federation of workmen, composed of an aggregation of syndicates dependent upon what is called in France "le Livre," that is, the printing and allied trades. This Federation is the most important workers' federation in France. The greater number, indeed, of the funds for "insurance against unemployment" in France have had no real importance. As far back as 1902 it was contended that the influence of previous legislation, dating from 1852, when it was expressly forbidden to any workers' organization to distribute out-of-work aid, still made itself felt. Obviously, legislation of this sort was monstrous, opposed to common prudence, and, therefore, to ethics. It was feared then that insurance against unemployment would facilitate strikes. At the present time the working population of France takes the greatest liberties in regard to strikes, and there is no longer anything in the way of legislation to prevent it from practising unemployment insurance or seeking the security of an association, or, at the least, from paying contributions in order subsequently to receive assistance should unemployment occur. In considering the insufficient character of the funds assigned to meet critical periods of unemployment, many people have been led to demand, from the State and the municipalities or departments of France, the allotment of premiums of encouragement to the workers' organizations, so as to induce them to practise what is called "unemployment insurance." In 1902, for example, it is the fact that beyond the funds under the control of "le Livre," the lithographers, the hatters, and the molders, the whole of France did not possess more than 110 funds for the various callings into which the working population was divided, and these 110 funds had distributed in one year less than 60,000 francs ($12.000) in aid of unemployment. Even the federation of "le Livre," notwithstanding its exceptional organization, was, in 1900, only hoping to arrange for something definite with regard to the matter of unemployment. Indeed, the funds of this federation were, so to speak, continually in arrear, the resources being utilized to cover the sickness risk as well as the risk of unemployment proper. Again, in this federation, the number of out-of-work days increased from year to year in a manner wholly unforeseen. It is easy, therefore, to understand that in the case of funds less well organized, the likelihood of the regulations being sufficiently well devised to avoid the various inconveniences that might arise was remote. In the case of the plaster-molders and molders of Limoges, it is admitted that out-of-work benefit may be continued for an indefinite period. This is an arrangement which certainly does not operate as an inducement to the assured—the workman whose contributions have formed part of the fund—to seek work.

Since 1896 certain towns—Dijon and Limoges, for example, where socialism has considerable influence—have granted subsidies to the funds for the relief of unemployment, and to this we shall refer later. As regards State subventions, legislative provision has been demanded since 1895, and between 1895 and 1903 various legislative proposals were submitted by deputies with the object of instituting a general insurance against unemployment, embracing all French workers. These proposals were never debated. In the end the question was submitted to the Conseil superieur du Travail, specially composed of members elected either by the employers' or works' syndicates or by the workmen's associations, and of members nominated by the government, and in this council the tendencies of the Socialist and Interventionist have been manifest. Nevertheless, the Council has not pronounced in favor of compulsory insurance, but has merely requested that the State should step in for the purpose of distributing grants to the organizations intended to aid workmen out of employment. As a consequence of all this, by the Financial Law of April 22nd, 1905, Parliament decided that a preliminary sum of 110,000 francs should be appropriated by the government to subventions to the funds in aid of involuntary idleness.

According to this law and certain subsequent modifications, all the funds which grant aids to members who are idle, by reason of failure to get work, have a right to State subsidies; only this form of unemployment is considered, to the exclusion of all others. Moreover, it does not matter whether the assistance to the unemployed workman takes the form of relief in a particular place or guarantees of traveling expenses, etc. In principle, it is essential that the funds applying for subsidies should be composed of members occupied in the same or a similar trade or calling. These funds should have at least 100 members, but 50 is sufficient if they already receive help from the local authorities. This course has been taken in order to obviate the differences in the risks of unemployment, and to facilitate the control of the workless men. Nevertheless, in towns of less than 50,000 inhabitants, local funds which group adherents of various trades may receive subventions, provided they have a minimum membership of fifty, and are subsidized by the commune or department. Also, grants may be allocated to funds distributing traveling expenses, and depending upon unions fed by the payments of affiliated associations, on condition that the resources of these associations have their origin in the contributions of the members. Subventions may also be accorded to syndicate funds and to certain philanthropic institutions and associations for mutual aid, or to others, but it is necessary that the fund soliciting such subventions should have been in existence six months, should guarantee a gratuitous service for finding work for men, and should submit its rules to the Minister, so that he may become acquainted with them. In addition, it is required that certain clauses should form part of the rules and regulations of the associations seeking and obtaining the subsidies. Thus the rules should indicate quite clearly instances of aid given to the unemployed, the duration of such aid, and the amount collected for assistance during enforced idleness. For the rest, the associations thus subsidized are free to fix the amount of their contributions and the rate and duration of benefits. It is nevertheless prescribed that the members of the associations subsidized should have no right to benefit until after an affiliation of six months, and that they should undertake to accept any employment in their particular line which the fund might indicate. They must, also, during the ordinary hours of work, sign a control register at least three times weekly. Each association must keep proper account of its expenses, and should be able to substantiate in some way its roll of membership, as upon this membership its receipts are calculated. Further, the subsidies of the State may be allocated for benefit not exceeding two francs per day or sixty days in the year. Any excess of this sum or period is disregarded in the calculations for allotment of subsidies. To show the large part which the subsidies play in the resources of the associations, it should be pointed out that it is only necessary for the contributions of the active members to represent at least one-third of the benefit paid to the "out-of-works"; that is to say, the participation demanded from the members concerned covers only a fraction of the outlay.

The legislation relative to State subventions in favor of the funds for unemployment specified, at first, that the maximum rate of these subventions should not exceed 16 per cent of the amount of the benefits distributed by the funds to their members. It was admitted, however, that this proportion might rise to 24 per cent for funds which embraced at least three departments and numbered more than 1,000 members. That lack of enthusiasm for insurance against unemployment, or for any fixed provision, by the French workers' syndicates, even when they have the chance of receiving aid from the State, is shown by the circumstance that, after three years' experience, the credit of 110,000 francs available was never exceeded by the grants distributed. This being so, and as there was no wish to exercise economies in relation to the credits, it was decided that the rate of subvention should be increased.

This rate, it is said, can now be 20 per cent or 30 per cent, dependent on the distinction above indicated. It should be noted that the 20 per cent to 30 per cent is only calculated after the subsidies given by the communes or departments have been deducted; these do not enter into the account in estimating the grants which should be given by the State. On the other hand, as it was a common experience to meet with funds that had no real importance, it was determined that the State subsidies should not be allocated to funds other than those which had distributed at least 30 francs in the way of benefits during the half-year. This, of course, is very little. It would appear, however, from certain figures that the organizations for insurance against unemployment have made very little progress in France in spite of the ample provision made in the Budget. It has hardly been possible for the State to distribute completely the credit of 110,000 francs which is placed at its disposal. It has been necessary therefore to fix upon a maximum rate of benefits which will fully employ the available funds.

It is true that, at the commencement of 1905, the number of funds for assurance against unemployment which desired to benefit by the half-yearly allotments of the State was only about 71. This number had risen gradually to 97 at the end of 1907, and to 112 at the end of 1908. Again, in the case of certain of the funds, the subsidies have not been fully paid, because the organizations did not conform to the conditions laid down and outlined above. In effect, during 1905, only 47 funds, with approximately a mean number of members of 33,700, received subsidies. In 1909 the number subsidized was 94, with a mean number of members approximately 40,000. In the first place, the number of "out-of-works" aided by the contributions of the funds themselves, and by the subsidies of the State, was 6,650, while during the year 1909 the corresponding figure was 7,350. These figures indicate a large proportion of "out-of-works" both for 1909 and 1905. But we must not be misled with regard to these numbers. They are composed, in the case of each fund, by the addition of the "out-of-works" for both half-years, and consequently in many instances the same person is counted twice over. The figures given really correspond to the total number of cases of unemployment—not to that of the actual persons unemployed. During the year 1905 the benefits paid by the various societies in aid of unemployment amounted to 135,000 francs ($27,000). The State paid nearly 28,000 francs in subsidies, so that it may be said that the State grants play an enormous part in the provisions of out-of-work benefit. In 1909 for 168,000 francs ($33,600) paid in indemnities by the same funds, the subsidies exceeded 42,000 francs ($8,400). The latter figure represents benefit for 95,000 days of idleness. It is clear, therefore, that only a small minority of workmen have taken advantage of the financial sacrifices which the State has imposed upon itself. Notwithstanding this circumstance, it cannot be denied that these sacrifices are considerable in relation to the personal efforts of the members who contribute to the funds for unemployment, since the State grants represent more than one-fifth of the aid which the funds themselves are in a position to render to their members; in addition to which, the number of funds, as well as the insignificant number of workers taking part in the associations, show that the workmen care little about making any personal attempt to guarantee themselves against unemployment, even when they are certain of subsidies which the generosity of the contributors have made relatively so important. Again, we cannot be sure that the distribution of these subsidies does not leave room for fraud, for cases are heard of in which the associations have taken steps to secure the State grants and to distribute them among their members, without having paid to such members the aid which should come from their own resources; and sometimes, even, the beneficiaries of this distribution of State aid were not really the unemployed who had interests in the association. As a matter of fact, since 1905 certain frauds have only been checked as the result of accidental detection, and it is likely that many others have escaped discovery altogether.

It must not be forgotten that a large number of local funds in aid of unemployment are subsidized by the departments or communes. Of these we may give a few particulars. In 1910, eight departments and forty-one communes, situated among twenty-five departments, drew upon their budgets in order to grant subsidies and aids to the societies concerned, accordingly increasing the out-of-work benefit that the latter could distribute to their members. These subsidies amount to about 114,000 francs ($22,800). It may be said that this sum is insignificant, but the amount is based upon the general contributions, and consequently is demanded for all and each of the contributors, while there is no certainty that it is distributed to really deserving people. Moreover, this sum of 114,000 francs is increased by what may be termed charitable contributions in aid of unemployment, which the so-called "insurance against unemployment" associations distribute; this exaggerates still further, in the case of the associations concerned, the contrast between this form of benefit and ordinary insurance. The mode of division of the subsidies varies with the district or locality. Certain towns have adopted, at least in part, the method known as the "*système gantois*," practised in the town of Ghent. They restrict their aid to an increase of that paid by the funds. In other towns the amount of the subsidy is remitted to the fund itself, without any express stipulation, and the fund has the power to deal with it as it thinks proper. Certain towns again augment the contributions paid by the members of the fund; while others take as a basis for subsidy, the number of members, the contributions, and the financial position of the fund.

In short, if there is any conclusion to be drawn from the system instituted in France under this *régimé* of subsidies granted either by the State or by the local authorities, it would be simply that the encouragement thus afforded appears to have had little effect on the development of out-of-work funds.

Frequently in the case of municipal or departmental subsidies there are not enough funds which have either distributed sufficient aid, or, having done this, have a sufficient number of members to warrant the grant of the whole of the credits. The assumption is therefore that the people interested voluntarily forego these subsidies because the opposite course would involve some personal effort by compelling them to pay to the fund, and to make some attempt at self-help.

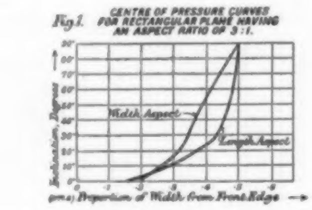
The Stability of Aeroplanes*

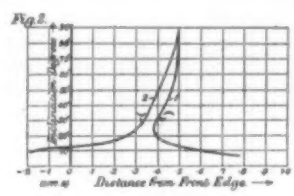
An Investigation of the Air Pressure on Aeroplane Surfaces

By A. P. Thurston, B.Sc.

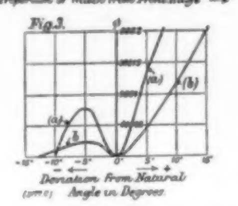
When an aeroplane of any shape is placed at various angles in a current of air, it is found that the point at which the pressure acts, i. e., the center of pressure—varies with every inclination. This variation, or travel, of the point of application of the center of pressure differs with every section and plan-shape of aerocurve or aeroplane. With certain aerocurves, and with all aeroplanes, the center of pressure appears to travel continuously towards the front edge as the inclination is continuously decreased.

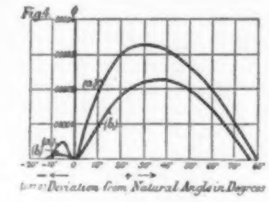
In Fig. 1 is shown the locus of the center of pressure for rectangles having an aspect ratio of 3 to 1 in "length" and "width aspects." In both cases the center of pressure continuously advances with decrease of inclination.





Figs. 1, 2—Locus of Center of Pressure at Different Inclinations.





Figs. 3, 4—Stability Curves for Rectangular Planes. Fig. 3 is an Enlarged Detail of Fig. 4.

Fig. 2 shows a similar locus for an aerocurve having a camber of one-twelfth span, and an aspect ratio of 3:2; curve 2 representing the hollow upward, and curve 1 the hollow downward. The curve 2 indicates strong stability, and the curve 1 an absence of stability. These and the following curves of the center of pressure were taken three-sixteenths inch above the highest point in the plane, the greatest dimension of the plane being 9 inches. The author finds it preferable to obtain corresponding curves in addition, below the planes, since the resultant pressure becomes more inclined to the normal as the inclination of the plane is decreased. Then, by the combination of the two curves so obtained, it is possible to find the travel of the center of pressure for any other parallel line.

The automatic stability of a flying-machine depends upon the continuous travel of the center of pressure towards the front edge with decrease of inclination.

The center of gravity and the center of pressure coincide under normal conditions when a flying-machine is running at the natural angle and speed, but when the angle is too small the center of pressure approaches the front edge and forms, with the weight, a couple tending to restore the machine to its natural inclination. Conversely, if the inclination is too great, the center of pressure travels behind the center of gravity and forms a couple tending to decrease inclination.

It follows, as the first necessary condition for maximum automatic stability, that the travel of the center of pressure to either side of the center of gravity should be a maximum for a minimum alteration in the angle of inclination.

As the second condition, it follows that the moment of inertia of the machine about a lateral axis through the center of gravity should be a minimum, since the inertia of the machine resists the action of the restoring couples.

The restoring couple at any point is the product of the lift by its distance from the vertical through the center of gravity. Since the lift is a function in the equation of stability, it follows, as the third condition for maximum stability, that the decrease of "lift" with decrease of inclination should be a minimum. In the ideal condition the lift should increase as the inclination is decreased from the natural angle. This is, of course, impossible in practice. If, when a machine has received a small displacement from the natural angle, a perpendicular through the center of lift is drawn to cut the line which passes through the center of gravity, and which is perpendicular when the machine is at the natural inclination, a point is obtained the position of which affects the stability of the machine. This point, which, to coin an expression, might be called the "phugoid center," corresponds to the "meta-center" of vessels, and its height above the center of gravity gives a measure of the longitudinal stability of a flying-machine.

Another method of examining the stability of a machine is by plotting the product of the lift by its distance from the vertical through the center of gravity. The stability curves, or curves of restoring torque, so obtained, graphically set forth the stability of a machine.

In Figs. 3 and 4 are shown the stability curves of rectangular planes having aspect ratios of 3:1 when in "length" and "width aspect," respectively. Models were made and the centers of gravity carefully adjusted until the best flights were obtained. Good flights were obtained when the center of gravity was 0.28 of the width from the front edge. The models were then pivoted about these points, and the vertical torque resisting a displacement from the natural inclination was measured, and is plotted in Figs. 3 and 4.

Fig. 3 is an enlargement of a portion of Fig. 4. Curve (*a*) shows the plane in "length aspect," and curve (*b*) in "width aspect." The rectangle in "length aspect" clearly has a much greater stability than the same rectangle in "width aspect." The restoring torque $= \phi\ w\ A\ V^2$ pound-feet, where ϕ is the stability coefficient for any deviation from the natural flying angle, and is read from the diagrams (Figs. 3 and 4).

w = width of plane, back to front, in feet taken in the direction of motion.

A = area in square feet.

V = velocity in miles per hour.

The stability of a machine may be increased by placing a second or rider plane in front of, or behind, the main plane. For maximum efficiency in flight, the main plane should have the shape and area giving the maximum life efficiency, i. e., it should be approximately a rectangle in "length aspect." The shape of the main plane being thus fixed, we are only able to vary the shape and disposition of the rider plane for the purpose of increasing the stability. Now the travel of the center of pressure might be increased if it were possible to cause the pressure on a front rider plane to decrease at less rate than the pressure on the main plane, and, conversely, with a tail rider plane to decrease at a greater rate than that on the main plane. This result may be obtained by each or all of the following means:

(*a*) Placing a front rider plane at a positive angle with the main plane, i. e., at a greater angle to the air than the main plane, and a rear rider at a negative angle, i. e., at a less angle to the air.

(*b*) By utilizing the "wake" of the front plane to affect the back plane.

(*c*) By the use of certain shapes and aspects of planes for the front and rear respectively.

(*a*) If the front rider is at a positive angle, then, as the inclination decreases, it is obvious that the pressure on the main plane will decrease at a greater rate than that on the rider, since the rider will still be lifting when an angle is reached at which the main plane ceases to lift. Conversely, if the rider is set at a negative angle, then, as the inclination of the machine decreases, the front plane will reach an angle at which it ceases to lift, and upon a still further decrease in inclination the air will act upon the top of it and introduce a depressing force. This force will oppose the couple introduced by the travel of the center of pressure. Thus it follows that a front rider should be set at a positive angle with the main plane. From similar reasoning it follows that a tail rider should be set at a negative angle with the main plane.

It will be seen that the Wright disposition with the front rider at a negative angle decreases the natural stability of a machine.

(*b*) Too little attention appears to have been paid to the utilization of the "wake effects" for increasing the stability of a machine.

The air which is engaged by an aeroplane is deflected downward. This downward deflection is not confined to the air in the immediate "run" of the aeroplane, but extends to a considerable distance above and below the plane, particularly above. The "field" of an aeroplane is therefore greater than its "run."

Some original stream-line photographs taken in a current of air having a speed of 1,800 feet per minute are shown in Figs. 5, 6, 7, 8, 9, 10 and 11.

In Figs. 5 and 6 the air considerably above the plane is influenced. In Fig. 7 the air divides at the

* Reproduced from *Engineering*.

Fig. 5.

Fig. 6.

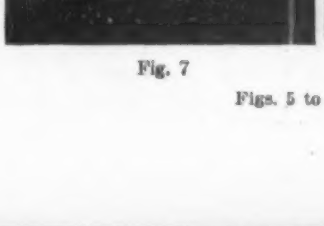


Fig. 7

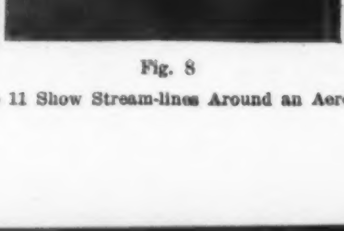


Fig. 8

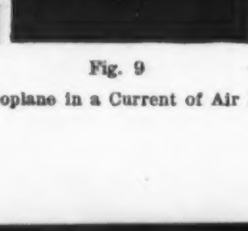


Fig. 9

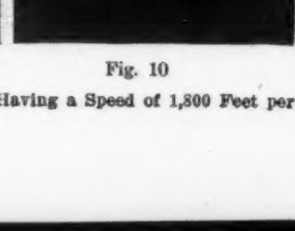


Fig. 10

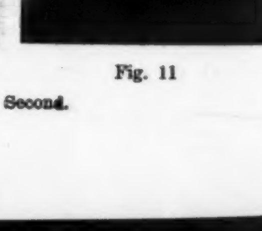
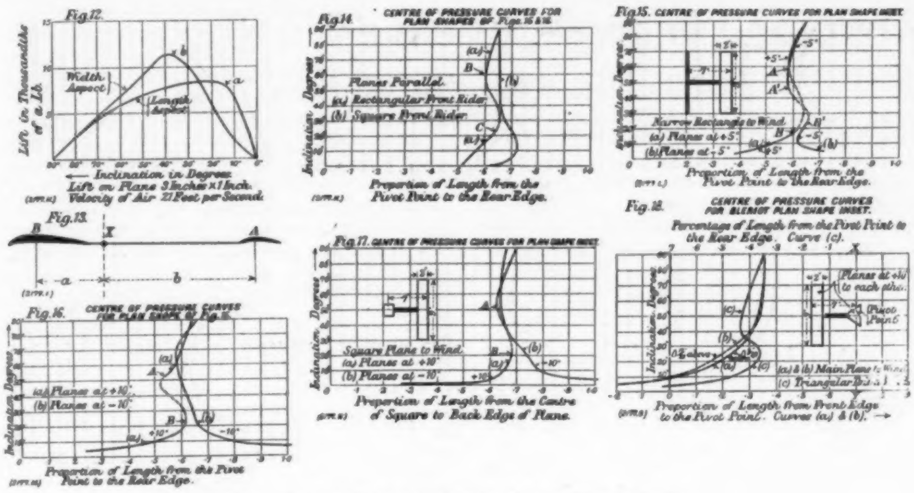


Fig. 11

Figs. 5 to 11 Show Stream-lines Around an Aeroplane in a Current of Air Having a Speed of 1,800 Feet per Second.

front of the plane, closely hugging the under-side and forming a "surface of discontinuity" on the back. Fig. 8 shows the compression under the plane, and the upward spring at the rear to counteract the suction above. Fig. 9 shows the gentle downward deflection imposed on the air below the rear edge of the plane. Figs. 10 and 11 show the action of the upper and lower planes of a biplane on the air.



Figs. 12 to 18—Lift and Center of Pressure Curves.

From these photographs it will be seen that the air at the rear of an aeroplane is in a considerable state of agitation, which varies from point to point. Now the lifting effect of this air in the wake is not so good as that of undisturbed air; moreover, since this air has on the average a downward deflection, an effect is obtained on a rear plane similar to that obtained by placing it at a negative angle with the front plane. Thus the stability may be increased by placing the rear plane in the wake of the first plane. But there is an additional effect to be obtained by utilizing the wake.

Our purpose is to arrange that the lift on the rear plane shall decrease at a greater rate than that on the front plane. Since the lifting effect of the wake is not so good as that of undisturbed air, it follows that our object may be obtained by arranging the rear plane to enter the wake when the inclination is decreased, and to come out of it into the free air when the inclination is increased. The best place for mounting the rear plane to obtain the maximum effect by this means can only be obtained by experiment and by drawing the stability curves as in Figs. 3 and 4, and the curves for the travel of the center of pressure as in Figs. 1 and 2.

(c) The third method of increasing the stability is by the use of rider planes having certain shapes and aspects.

Now we may use square, rectangular, circular, semicircular, triangular, or other plan shape for our rider planes. Of these shapes, a rectangle in "length aspect," and having the greatest aspect ratio, has a greater lift per unit area at small angles than any other shape.

In Fig. 12, which is derived from Dr. Stanton's experiments on a plane having an aspect ratio of 3:1, the lift on the plane in "length aspect" at angles between 0 degree and 20 degrees (curve *a*) is much greater than that on the plane in "width aspect" (curve *b*). Moreover, for angles above 2 degrees the pressure decreases proportionately (curve *a*) at a less rate than in the case of the same rectangle in "width aspect" (curve *b*). Therefore a rectangle in "length aspect," and having a large aspect ratio, is the best shape for a front rider.

The shape of plane having the greatest proportional decrease with inclination appears to be either a triangle with the apex to the wind, or a rectangle in "width aspect." The author has not yet been able to demonstrate the truth of this statement as regards the triangle. It is clear that there is a greater proportional decrease with inclination for planes having a smaller "width aspect." Therefore it follows that the tail plane should have a smaller aspect ratio than the front plane.

The center of area of a triangle with its apex to the wind would be farther from the center of gravity of the machine than the center of area of a rectangle of equal area in "width aspect." A greater restoring torque would therefore be obtained. Moreover, for equal areas of tail-planes, a triangular tail would have double the span of a rectangular plane, and therefore take approximately double the advantage of the wake effect. It would thus appear from these considerations that a tail rider plane should preferably be triangular, with the apex towards the wind. Conditions (*b*) and (*c*) appear to require aspect ratios of opposite values, and therefore it follows that the relation of the dimensions should be fixed by experiments.

The problem of stability is not completely solved by the provision of a suitable restoring couple. It is necessary to provide, in addition, an efficient damping couple to damp out any oscillation which may be set up. This damping couple is provided by the resistance offered to the planes as they oscillate in the air about the center of gravity of the machine.

If in Fig. 13

A = area of the tail-plane A.

B = area of the main plane B.

Then $A \times b = B \times a$, since the lift is approximately proportional to area.

Therefore, since the area of the main plane B and the distance a are constant, $A \times b$ must equal a constant.

Now for a given angular velocity of oscillation about the center of gravity X, the velocity v of the plane A is proportional to the distance b.

Also the resistance offered by the air to a plane is proportional to the square of the velocity.

Therefore, the damping couple introduced by the rider plane A = resistance $\times b$, i. e., it varies as $v^2 \times A \times b$, but v is proportional to b.

Therefore, the damping couple is proportional to $A\ b^3$ or to $A\ b\ (b^2)$, i. e., the damping couple provided by rider planes having equal control torques increases as the square of the distance from the center of gravity. The distance between the planes should therefore be as large as is practicable. Also it follows that a triangular tail gives a more powerful damping action than a rectangular "width-aspect" tail.

From the previous reasoning it would appear that for maximum longitudinal stability—

1. With the rider plane in front, the rider should have a large aspect ratio in "length aspect," and a long span approximating to that of the rear main plane.

2. With the rider plane behind, the rider should have a smaller aspect ratio than the front main plane, and should preferably be triangular with the apex toward the wind and placed so as to take advantage of the wake effects.

3. In both cases the rider plane should be set as far as possible (within limits) from the main plane, the planes should be set at a positive angle with each other, and the moment of inertia of the machine should be a minimum.

Center-of-pressure curves for flying machines of various plane shapes and dispositions are shown in Figs. 14, 15, 16, 17, and 18. In all these cases the main plane was rectangular, 9 inches by 2 inches. The aspect ratio was thus 4½:1. This rectangle was fixed to one end of a rib with its length at right angles. Rider planes were adapted to be pivoted at the other end of the rib 7 inches from the outside long edge of the main plane.

The curve (*a*), Fig. 14, was obtained with a front rider plane 9 inches by ½ inch in length aspect. Its aspect ratio was therefore 18:1. Curve (*b*) is a corresponding curve with a square front rider of equal area to the last. In both cases the rider and main planes were parallel. The increased stability obtained by the rectangular rider is apparent. If allowance is made for the increased longitudinal length of the model with the square front rider, the superiority of the rectangular rider is still more marked.

Curve (*a*), between the points B and C, was found to be unstable, it being found impossible to obtain definite points of balance.

Fig. 15 shows curves (*a*) (*b*) obtained with the first model, having the rectangular front rider at a positive and negative angle of 5 degrees respectively. Curve (*a*) was obtained with the rider at +5 degrees with the main plane. This disposition gives a strong stability. In curve (*b*) with the rider set at a negative angle with the main plane, as in the Wright disposition, there is instability, the center of pressure traveling toward the rear for all decreases of angle below 13 degrees. These curves were also found to be unstable between the points A, B and A^1, B^1.

Curves (*a*) and (*b*), Fig. 16, show the same model with the rectangular front rider at +10 degrees and —10 degrees respectively. Curve (*a*), with the rider at +10 degrees, shows a stronger stability than the previous curve (*a*) of Fig. 15, and curve (*b*) shows a corresponding greater instability. Again, it was found impossible to obtain definite readings between the points A and B, but no such difficulty was found with curve (*b*).

Fig. 17 shows curves corresponding to those in Fig. 16, but with a square front rider of equal area. The planes are set at +10 degrees and —10 degrees respectively in curves (*a*) and (*b*). These curves are very similar in characteristic shape to those of Fig. 16, but in neither case is the stability or instability so strong. The portions of the curves indicating the stability lie between 3 degrees and 15 degrees. It is clear that the travel of the curves between these inclinations is smaller in Fig. 17 than in Fig. 16. Curve (*a*) is discontinuous between the points A and B.

Fig. 18 shows the center of pressure curve for a Blériot disposition with a rectangular main plane and a triangular tail rider. The planes were in all cases at +10 degrees to each other. Curve (*a*) shows great stability. The center of pressure travels in front of the front edge of the main plane. The equilateral triangular plane was pivoted at its centroid and had an area equal to the square and rectangular riders previously used. It was mounted at the rear of the main plane, with its apex to the wind. In curve (*a*) the triangular plane was mounted 9/32 inch below the main plane, and in curve (*b*) 17/32 inch above. The difference in the curves (*a*) and (*b*) is therefore to be attributed solely to the difference in the wake effects. Curve (*a*) gives a superior stability to curve (*b*). Curve (*c*) was obtained with the model used in curve (*a*), the current of air being reversed. Thus the main plane became a rear plane, and the triangular tail a front elevator with the base to the wind. The line $X\ Y$ is the vertical base line for this curve, and corresponds with the back of the main plane. Curve (*c*) has been superposed on curves (*a*) and (*b*) to show the effect of plane shape and disposition on the travel of the center of pressure and the stability.

All the photographs and curves, with the exception of Fig. 12, were taken in the aerodynamical laboratory of the East London College (University of London) by members of the Aeronautical Research Society. The writer's thanks are due to Messrs. H. K. Pettit, E. Tindall Cook, and A. G. Field, for valuable assistance in taking readings and photographs, or constructing apparatus.

Distribution of Germs in the Air

SOME interesting experiments have recently been made by Gaston Bonnier, together with Matruchot and Combes, with regard to the distribution of microscopic germs in the air. The air to be tested was sucked by means of an aspirator through a glass vessel containing a suitable nutrient solution, so that the germs could develop rapidly. If the temperature sank below 20 degrees, the solution solidified. It was possible not only to count the organisms which developed, but also to make a systematic observation of their development and photograph them. The nutrient solution employed was prepared from potatoes, carrots, and similar materials. The flora of vegetable organisms obtained varied according to the locality and according to the nature of the culture medium (nutrient solution) employed. Fifty liters of air taken from the wood of the high land of Fontainebleau produced on carrots 1,809 colonies, on beet preparation 336, and in lemon preparation no colonies. On the contrary, at an open, rocky spot in the forest, the lemon culture also showed numerous colonies. Great differences were also observed between samples taken from different points at equal levels and with the same nutrient solution. Thus, for instance, in one case, a sample collected at a considerable distance from the forest showed 51, a sample from the skirts of the forest 120, and one from the heart of the forest 13,600 fungus germs. The number of organisms decreased very rapidly as the height above the sea level increased, a fact which had long been observed with regard to bacteria by Pasteur and others. Fungus germs in particular also decreased rapidly with increasing height; thus, 50 liters of air from the Alps of the Dauphiné, at a height of 260 meters, showed 226 fungi and 41 bacteria. A sample from a height of 1,020 meters showed 184 fungi and 2 bacteria; from 1,125 meters, 170 fungi and no bacteria; from 2,190 meters, 64 fungi and no bacteria. Snow collected aseptically at a height of 2,860 meters developed numerous fungus colonies.—*Umschau.*

The Senses of Plants

Their Reaction to Various Stimuli

I

The investigation of modern plant physiologists with regard to the functional activities of both lower and higher forms of vegetable life have demonstrated clearly that plants may be considered, in a broad general sense, to possess *senses*. In other words they are capable in varying degree of some sort of *perception* of environment, of *reaction* to the stimulus thus received, and even, apparently, of *discrimination* in response.

In a recent number of *La Revue* this fascinating subject is dealt with entertainingly by M. Henri Coupin. We abridge and condense his article as follows:

The most highly developed sense belonging to plants is that of *sight*, which permits them to perceive *light*, but not to distinguish objects, a faculty found among a number of animals, such as earth-worms, oysters, coral, etc., which have no localized visual organ, but indicate susceptibility to luminous impressions by contraction when struck by a ray of sunlight.

It is easy to show the influence of light on plants by cultivating one in a room with a single window. The stalks, as they grow, will turn toward the window, i.e., they are *positively* heliotropic. This sensibility to light is also found in the roots, but these *shun* the light; they are *negatively heliotropic*.

This is a general law, and even the leaves, which seem the mere sport of the wind, obey it. At night they "*sleep*," that is, they assume a special position. During the day they most frequently dispose themselves in such manner as to receive the rays of light perpendicular to their surface. Some species are peculiarly sensitive in this respect, the best known example being the nasturtium. In the perception of light by leaves the epidermis of the upper surface seems to play the most important *rôle*. This epidermis is frequently composed of cells which are really tiny convex lenses. These reflect and collect the rays like the ordinary burning-glass. Thus the subjacent cells receive the light in the form of bright dots surrounded by darker zones, and the position of these varies accordingly to the slant of the leaf. This concentrated light exerts a stimulus or irritation on the protoplasm of the cells, and the stimulus is transmitted to the stems, which respond by so bending and twisting as always to keep the leaf in its position perpendicular to the rays. The German physiologist Haberlandt showed this cell-action convincingly by photographing under the microscope fragments of this cell-bearing epidermis. The fact is easy to demonstrate with the honey-suckle leaf. In this case all the cells exhibit the phenomena; in others, balsam, for example, the power is confined to particular cells. Haberlandt does not hesitate to call these privileged cells "eyes" and to compare them to those very simple eyes known as ocelli found in spiders and many insects.

The most simple plants lend themselves still better to the study of the influence of light, especially those microscopic algæ which abound in water and have the power of motion. Take for instance the greenish water found in gutters and put some of it in a glass tube covered with lamp-black pierced by apertures. For example, write a word on the lamp-black, such as *La Revue*. Let it stand in the sunshine for a few hours, or still better, leave it for a day or two. Then wipe off the lamp-black with a piece of linen and you will see within the tube the words *La Revue* written in green letters. The mobile algæ to whose presence is due the tint of the water have been attracted by the light and have localized themselves wherever it penetrated, i. e., along the letters of the words. They remind one of crowds rushing to a window to watch some scene in the street!

Many algæ, too, are marked by a clear red dot which strangely resembles an eye and possibly has similar functions. The most frequent type are the *chlamydomonads;* these swim in the water by means of two vibratory hairs, and seem to go straight to their goal. Still others, not being able to swim, move along the wall of the vessel containing them toward the light-ray that attracts them by a series of agile revolutions that would do credit to a clown.

II.

A sense equally wide-spread among plants is that of *touch*. The best known case is that of the sensitive plant, which at the slightest contact folds its leaflets together and finally lets the whole leaf droop.

Of late years the movements of the sensitive plant have been closely studied and there has been detected a tissue of slightly elongated cells communicating with each other by minute passages, and admirably adapted, like a network of nerves for conveying the tactile sensation to the rest of the plant, which, for reasons that escape us, changes the tension of its aqueous system, whence arise the leaf-movements we observe.

Another leaf, likewise extremely sensitive, is that of Venus' fly-trap, or dionoea, which is composed of a flat blade terminating in two appendages that fit together and revolve around a central hinge. This union occurs frequently when an insect alights on the trap, which is immediately sprung, and catches the intruder, whence its name. In seeking to cause the movement it is found to be produced with certainty only when one of the three small hairs inside the trap is touched. Here, then the same sense of touch is clearly localized and we might say, indeed, that the plant has veritable tactile organs, such as are found in the epidermis of most animals.

Consider, too, the actions of *tendrils*, those organs by which many plants attach themselves to neighboring objects, as everyone has seen vines and melons do. If they meet no support while growing they remain almost straight, but, if by chance they stumble against a twig, within a few hours they have twined about it. The sensation of contact has stimulated them to this formation of ringlets. Moreover, the excitation produced is transmitted to a certain distance, so that the tendril will continue to twine even below the point of contact and thereby brings the plant nearer to the supporting object. The twining may even be reduced by stroking the tendril repeatedly on the same side.

Among flowers we find many examples of phenomena due to tactile sensations. Touch, for example, the base of the stamen of the barberry with a pin; instantly it will fold against the pistil, the central organ of the flower. The movement is very rapid, lasts only a few seconds, and the stamen flies back to its original position when the excitation ceases. Do the same with a certain little wall-flower, the parietary, and the movement is even more abrupt. The stamens fly back like little springs, discharging their pollen in every direction. In both these instances—to which it would be easy to add others, such as the movements of the stamens of thistles—the phenomenon has been produced solely by touch.

III.

The sense of *taste* certainly exists in the lower orders of plants, such as the algæ to which I referred above in speaking of phototropism. If we place in the water in which they live, particles of diverse nature, it will be seen that only certain ones of these will be assimilated. To the surface of these the algæ will cling while the others will be disdained. The algæ, therefore, are capable of perceiving the savor of their aliments and making choice among them, and this faculty we call taste.

Taste is more difficult to detect among the higher plants, among which it is probably not very wide-spread. However, when one places on the leaf of a carnivorous plant, the sun-dew, an insect or a scrap of meat, the tentacles with which it is covered will seize these substances, while they remain inert in the presence of non-nutritive matters, such as a pebble. The tentacles, therefore, manifest a sense of taste by their behavior Besides, if one examines them under the microscope it will be seen that when in contact with a sapid substance their protoplasm is agitated; it seems to fairly thrill with pleasure! Moreover, the extremity of the tentacles secretes larger quantities of a sticky juice under such conditions. We might say without too much exaggeration—that its mouth is watering!

Besides the senses of sight, touch, and taste which we have just described, plants possess a special sense which may be called that of *direction in space*. Place in a horizontal position a root previously vertical and it will almost immediately begin to direct itself, at the extremity, toward the center of the earth. Do the same with a stalk and it will direct itself in the contrary direction, toward the zenith. Suspend a flower pot containing growing bean-plants upside down, and the next day you will find that the leaves have twisted to present anew their faces to the celestial vault. The physiologists call these phenomena *geotropism*. This sense is highly developed in the vegetable world, and plants react to the sensory stimulus with never-failing certainty and precision.

Electric Waves Directed by Wires*

Their Use in Multiplex Telephony and Telegraphy

By Major George O. Squier, Ph.D.

During the past twelve years the achievements of wireless telegraphy have been truly marvelous. From an engineering viewpoint, the wonder of it all is, that, with the transmitting energy being radiated out over the surface of the earth in all directions, enough of this energy is delivered at a single point on the circumference of a circle, of which the transmitting antenna is approximately the center, to operate successfully suitable receiving devices by which the electromagnetic waves are translated into intelligence.

The "plant efficiency" for electrical energy in the best of wireless stations yet produced is so low that there can be no comparison between it and the least efficient transmission of energy by conducting wires.

The limits of audibility, being physiological functions, are well known to vary considerably, but they may be taken to be in the neighborhood of 16 complete cycles per second as the lower limit and 15,000 to 20,000 cycles per second as the upper limit. If, therefore, there are impressed upon a wire circuit for transmitting intelligence harmonic electromotive forces of frequencies between 0 and 16 cycles per second, or, again, above 15,000 to 20,000 cycles per second it would seem certain that whatever effects such electric wave frequencies produced upon metallic lines, the present apparatus employed in operating them could not translate these effects into audible signals.

The electromagnetic spectrum at present extends from about four to eight periods per second, such as are employed upon ocean cables, to the shortest waves of ultra-violet light. In this whole range of frequencies there are two distinct intervals which have not as yet been used, viz., frequencies from about 3×10^{13} of the extreme infra-red to 5×10^{10}, which is the frequency of the shortest electric waves yet produced by electrical apparatus, and from about 80,000 to 100,000 cycles per second to about 15,000 to 20,000 cycles per second. The upper limit of this latter interval represents about the lowest frequencies yet employed for long distance wireless telegraphy.

Within the past few years generators have been developed in the United States giving an output of two kilowatts and above at a frequency of 100,000 cycles per second, and also capable of being operated satisfactorily at as low a frequency as 20,000 cycles per second. Furthermore, these machines give a practically pure sine wave.

The necessary conditions for telephony by electric waves guided by wires are an uninterrupted source of sustained oscillations, and some form of receiving device which is quantitative in its action. In the experiments described in multiplex telephony and telegraphy it has been necessary and sufficient to combine the present engineering practice of wire telephony and telegraphy with the engineering practice of wireless telephony and telegraphy.

The frequencies involved in telephony over wires do not exceed 1,800 to 2,000, and for such frequencies the telephonic currents are fairly well distributed throughout the cross section of the conductor. As the frequency is increased the so-called "skin effect" becomes noticeable, and the energy is more and more transmitted in the ether surrounding the conductor.

At frequencies of 100,000 cycles on wire circuits the phenomena may be considered as a "super-skin effect" or "film effect," where the actual mass of the metal conductor involved is but a small fraction of the total.

At such frequencies the flow of energy is controlled by reactances in the ether surrounding the conductor, rather than by the ohmic resistance of the wire as in battery telephony and telegraphy, and when these reactances are balanced at the receiving end of the circuit by the process of electrical "tuning" the one hundred thousand small packages of energy in the form of electromagnetic waves, which are delivered in each second of time at the receiving end of the circuit are thus added together to produce a cumulative effect many times greater than may be obtained without such electrical tuning process.

* Synopsis of lecture delivered before the New York Electrical Society, at its 304th meeting, Oct. 27th, 1911.

These waves are guided by wires with the velocity of light in free space, and are made the "carrier" of telephonic or telegraphic messages, or both, according to the principles used in the wireless arts.

Extra ethereal "channels" of intercommunication are by these means provided without the expense of erection and maintenance of special wires for the purpose.

Furthermore, it has been found possible to superimpose, upon the ordinary telephonic wire circuits now commercially used, electric waves of ultra-sound frequencies without producing any harmful effects upon the operation of the existing telephonic service. Fortunately, therefore, the experiments described are constructive and additive, rather than destructive and supplantive.

Electric waves of ultra-sound frequencies are guided by means of wires of an existing commercial installation and are made the vehicle for the transmission of additional telephonic and telegraphic messages.

The cource of electric waves used in the experiments described was a special type of dynamo, capable of producing 100,000 cycles per second and also capable of operating regularly at 20,000 cycles. This gave a wide range of frequencies for tests over an actual commercial telephone line of about 776 ohms. resistance and capacity of 0.7 microfarad. The cable being lead covered throughout, it practically corresponded to a submarine cable about seven miles in length. The generator was of the inductor type and the rotor operated at a speed of 20,000 revolutions per minute or would roll as a wheel from the United States to Europe in four hours. The friction, or adhesion, of the air against the rotor was so great at this speed, as to require 5 killowatt to overcome this alone, although the total output of the machine is but 2 killowatt.

Severe tests were described to determine the efficiency of a single wire with earth connection as a circuit for commercial telephony by high frequency methods, and these tests showed that such circuits are entirely practicable for this work, thus doing away with the necessity of constructing two wires for a telephone toll circuit as is now required.

Since the inductances and capacities required for this range of frequencies are a thousand times smaller than those employed in battery signalling, the complete and absolute separation of two independent telephonic conversations on the same pair of wires was readily obtained.

The engineering data obtained from a study of this particular cable line were presented in the form of typical resonance and selectivity curves at frequencies ranging from 20,000 to 100,000 cycles per second.

The transmission of energy at these ultra-audible frequencies was so radically different from the phenomina at low frequencies by metallic conduction, that the results very closely resembled pure radio-telegraphy. The energy waves were broken away from the source as from a transmitting antenna and thereafter had no perceptible reactive effect upon the source at the transmitting station. It was, therefore, not possible to tell from the transmitting station whether or not the distant end of the line was open or "shorted."

Resonance curves at the receiving end of the line were shown, also attenuation curves over a wide range of frequencies.

Since the loss of energy on the metallic "film" of the line in transmission is proportional to the *square* of the line current, it is permissible to put the energy in any form desirable for transmission and this is controlled by the ratio of transformation of the oscillation transformer at the transmitting station. With a ratio of but 1 to 5 excellent speech was obtained with a transmitting line current almost too small to be read on any commercial ammeter.

In battery telephony this ration is above 1 to 20, so that the line currents may be small and, therefore, line losses decreased inversely as the square.

The ringing circuit was operative both ways with no apparent effect on the high frequency telephone transmission. This ringing circuit develops a comparatively large alternating current flowing in the wire at about 30 cycles per second and at a voltage of many times that of either the high frequency or the battery side of the circuit.

Articulation tests, including music, numerals and other difficult combinations, gave satisfactory results, with no interference whatever between the two sides of the circuit.

By holding one telephone receiver to one ear and the other receiver to the other ear the receiving operator could hear two entirely different conversations simultaneously over the same pair of wires.

The distortion of speech, which is an inherent feature of telephony over wires, should be much less, if not practically absent, when we withdraw the phenomena more and more from the metal of the wire and confine them to a longitudinal strip of the ether which forms the region between the two wires of a metallic circuit.

The tuned electrical circuit at the receiving end readily admits electromagnetic waves of a certain definite frequency, and bars from entrance electromagnetic waves of other frequencies. This permits the possibility of utilizing a single circuit for multiplex telephony and telegraphy.

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

Prof. Cyril G. Hopkins has recently severely criticised Prof. Milton Whitney for teaching from the Bureau of Soils that (1) "Practically all soils contain sufficient plant food for good crop yields, so that this supply will be indefinitely maintained." (From Bureau of Soils Bulletin 22, page 64.)

Let us investigate. What is plant food? The principal, non-mineral, chemical elements composing the structure of plants (about 94 per cent) are oxygen, hydrogen, nitrogen, and carbon. Of these elements, carbon predominates in bulk.

Now the question is, will there ever come a time in the history of this world (as at present constituted) in which there will be any lack of these elements available for plant growth, supposing a sufficient rainfall and a thorough cultivation of the soil, whereby these elements are incorporated with its texture? Now the mineral elements constituting the great bulk of soil structure are all more or less soluble in water. Even silicon in its combinations with alkalies in the form of glass is slightly soluble in water, as has been demonstrated.

The next statement criticized by Prof. Hopkins is as follows:

(2) "The soil is the one indestructible, immutable asset that the nation possesses. It is the one resource that can not be exhausted; that can not be used up." (From Bureau of Soils Bulletin, 55, page 66.)

By the term soil (as I understand Prof. Whitney) is meant the mineral elements composing it.

These of course can never permanently be exhausted. Being thus understood, the position of Prof. Whitney is perfectly tenable. The difficulty arises from the fact that soil is of very complex structure, chemically speaking, and varies in its physical characteristics and general make-up.

Its fertility is likewise dependent on its many physical and chemical conditions.

Its fertility is also relative in respect to the plants grown upon it.

The writer has on his place in Florida soil over six feet deep and richer in plant food than ordinary stable manure. Yet to ordinary farm crops (in its present condition) it is very infertile.

Again, a cranberry bog is fertile to the cranberry plant, but the farmer would be considered a fool who would plant wheat on such a soil without first changing its physical and chemical conditions.

(3) "From the modern conception of the nature and purpose of the soil, it is evident that it can not wear out, that so far as the mineral food is concerned it will continue automatically to supply adequate quantities of the mineral plant food for crops." (From Bureau of Soils Bulletin 55, page 79.)

Prof. Whitney goes on to explain his position in the following paragraphs (Page 72, Bulletin 55, "Soils of United States"):

"The old idea of soil fertility was that plants could not avail themselves of the potash or phosphoric acid until the rock particles, the minerals, were decomposed and their constituents made available to the plants. It is, however, merely a question of the solubility of the mineral particles themselves. One can take the minerals obtained from the soil, or minerals from museum collections, and by grinding them up and adding water and a little nitrate, obtain a soil solution which is comparable with the soil solutions of our fields, and can grow as good plants in the extract from the cabinet specimens so prepared, as in the extract of the soil itself. The plants can avail themselves of the potash, phosphoric acid, and lime which are dissolved directly from these mineral particles. Not only so, but if we take these minerals and wash them by repeated leachings, we will continuously get quantities of potash, phosphoric acid, and lime dissolved in the water. After leaching, repeatedly and frequently, during the day, if we leave the particles in contact with a fresh portion of water over night, in the morning the concentration of the solution will be about the same as it was the morning before, so immediate and rapid is the recovery, and so adequate and ready is the supply of these mineral nutrients.

"We have in our soil moisture a solution which carries sufficient nutrients for the support of the plants. It is capable of maintaining its concentration by re-solution from the minerals to supply any portion of these plant food constituents that may be withdrawn. Under ordinary conditions of drainage and of rainfall, the concentration can not get too large, nor can it for any considerable period get too small for the need of plants. In other words, we have in the soil a most efficient system for supplying the mineral nutrient food for plants.

"This, therefore, is the nature of the soil and of the soil moisture. It is a great nutrient medium for the support of plants, spread out over the surface of the earth; and as all soils, with but possibly few and unimportant exceptions, are made up of a great number of minerals, it follows that the concentration and the composition of the soil moisture in our different types of soil varies but little."

(4) "As a national asset the soil is safe as a means of feeding mankind for untold ages to come. So far as our investigations show, the soil will not be exhausted of any one or all of its mineral plant food constituents. If the coal and iron give out, as it is predicted they will before long, the soil can be depended upon to furnish food, light, heat, and habitation not only for the present population, but for an enormously larger population than the world has at present." (From Bureau of Soils Bulletin, 55, page 80).

In his criticism of this paragraph, Prof. Hopkins ignores, or did not read, the voluminous evidence proving that the soils of Europe have not deteriorated in their plant food supplies, and further, that the yield of crops is greater on the same soils than in past ages. Prof. Hopkins supports his contention by citing the case of New England farms. He fails to see that the fact of faulty agriculture, rendering the soil, for the time being, infertile, does not necessarily prove an exhaustion of plant food.

The very process of renovation taking place in these soils at the present time proves their plant food was not exhausted, but that there is a lack of understanding of a proper system of crop rotation and soil cultivation.

A. T. CUZNER, M. D.

Gas Engineering and Refrigeration at the Massachusetts Institute of Technology

OUR attention has been drawn to special courses in gas engineering and refrigeration which have been established at the Massachusetts Institute of Technology.

"The course in gas engines will be cared for by Assistant Professor J. C. Riley, and will concern itself largely with the mechanics of the smaller engines. The gas engine looms up large as a future source of power, and combustion engines have made possible the automobile and aeroplane. The development along both of these industrial lines will be limited by the development in the engines, for one of its important factors. The gas-engine course is planned for third year students. It has proved to be a very popular course and no less than ten of the students in the department have chosen for their thesis work some line of research connected with internal combustion engines. Science ought certainly to be benefited by such work."

The course in refrigeration is probably a novelty in its completeness and its relations to other courses. It is true that some similar courses have been given elsewhere, but they have not been maintained. Prof. C. W. Berry will have charge of this course and the epitome of what is proposed is this: 1. The thermodynamics of the various refrigerants; 2. A study of the machines and refrigerative systems; 3. The insulating value of various materials and types of construction for warehouses, ice-plants, refrigerator cars and vessels; 4. The proper conduct of storages including circulation of air, ventilation, area of cooling surfaces and location, temperature and humidity; 5. Methods of manufacturing ice; and 6. Liquefaction of gases and preparation of commercial oxygen and nitrogen.

This course will not only serve the special purpose for which it is directly intended, but it grounds the student more firmly in thermodynamics.

The World's Production of Aluminium

THE *Frankfurter Zeitung* recently published the following interesting statement regarding the aluminium industry: "The development of the aluminium production has been unusually rapid, the world's production having risen from 11,500 metric tons in 1905 to 24,200 metric tons in 1909 and 34,000 metric tons in 1910. The distinctive feature about the aluminium trade is that it is in the hands of only twelve companies of which five, namely, the Aluminium Industrie Akt. Ges. of Neuhausen, the Société Electro-Metallurgique Française of Froges, the Compagnie des Products Chimiques d'Alais et de la Camargue of Salindres, the British Aluminium Company, Ltd., and the Aluminium Company of America, account for nine-tenths of the total output. The price of aluminium per kilogram was 27s. in 1890, 2s. in 1900, 3s. 3d. to 3s. 9d. in 1905, 1s. to 1s. 6d. in 1909, and 1s. 3d. to 1s. 7d. in 1910." The equivalent of the 1910 prices in United States money is 11.9 cents to 15.5 cents per pound.

Municipal Efficiency Bureau

A committee on Municipal Finance and Taxation of St. Louis, Mo., has recently issued an eight-page pamphlet, the aim of which is to exert influence toward the establishing in that city of a Municipal Efficiency Bureau or, as it is more commonly called, a Bureau of Municipal Research. This committee, states the *Municipal Journal*, has collected information concerning the workings of such bureaus in other cities. It found them actively at work in New York, Chicago, Philadelphia, Cincinnati, Milwaukee and Memphis. It defines such a bureau as "An institution designed to introduce into public administration the most economical methods of private business, to prevent waste and to provide an effective agency of citizens' inquiry—to ascertain exactly how the public business is being transacted, to bring this information to the people in digestible form, and on the basis of exact knowledge to assist city administrations in increasing efficiency."

It comments at greatest length upon the work of the New York Bureau of Municipal Research, which is credited with having saved the city several millions of dollars, some of the largest items of this being $400,000 from the Dock Department budget and $300,000 to $500,000 from the Fire Department budget. This bureau has reorganized from top to bottom the departments of Finance and Accounts, Division of Child Hygiene, Bureau of Licenses, Revenue Control in Water and Park departments, Bellevue Hospital clerical staff and the control of violations of the Tenement House Department. It has revised the city's accounting system, budget making methods, the method of computing school repairs and the city's debt, and the real estate bureau's records. It refers to the fact that ex-Comptroller Metz has donated a fund of $30,000 to encourage the introduction of accounting methods in other cities similar to those which this bureau has introduced in New York.

The costs of maintaining the bureaus in the several cities have been as follows: New York, $91,470, $87,660, $100,000 in 1908, 1909 and 1910, respectively; Chicago, $55,000 in 1910; Philadelphia $25,000 and $30,000 in 1909 and 1910, respectively; Cincinnati, $35,000 in 1910; Memphis, $12,000 in each of the years 1909 and 1910; Milwaukee, $25,000 in 1910. In New York the greater portion of the expenses is contributed by about one dozen citizens, although there are between 100 and 200 smaller contributors. In Chicago, fourteen men subscribed $114,000 and an additional $3,000 was sent unsolicited, this sum to carry the work through two years. The Philadelphia bureau is supported largely by the contributions of a small number of men, as is the case in Cincinnati. The cost of the Memphis bureau was obtained principally from small subscribers. Milwaukee is apparently the only city which supports such a bureau by public funds, $25,000 being appropriated for this purpose.

The objects which it is hoped to obtain by such a bureau and the methods of procedure are outlined in this pamphlet as follows:

SPECIFIC OBJECTS OF THE EFFICIENCY BUREAU.

1. To ascertain the powers and limitations of each city official; to eliminate conflicts of power and administrative jurisdiction, and to suggest methods of preventing waste and inefficiency.
2. To aid public officials in securing the information necessary to effective administration; to preserve such evidence of transactions as is necessary to locate responsibility, and to inform the public of service performed and the cost thereof.
3. To scrutinize the general system of accounting and make constructive suggestions for improvement.
4. To examine the methods of purchasing materials and supplies and the letting of contracts.
5. To improve budgetary proceedings and assist those who make appropriations in securing that classified and exact knowledge which is necessary to prevent carelessness and waste in appropriating the public funds.
6. To furnish the public with exact knowledge regarding public revenues and expenditures and thereby promote efficiency and economy in public service.

METHODS OF PROCEDURE.

1. Confer with public officials and secure their co-operation and that of their subordinates in remedial work.
2. Prepare a digest of the powers and duties of the department or office by an examination of the statutes, ordinances and rules pertaining thereto.
3. Prepare a chart of each department or office showing lines of authority.
4. Examine the public records, analyze the information contained therein, and make collateral inquiry concerning matters in which the records may be defective.
5. Compare functions and expenditures with work accomplished and results obtained.
6. Hold frequent conferences between members of the Bureau's staff and also between the staff and public officials on methods used and facts disclosed.
7. Submit formal report to officials on organization, powers, duties and present methods of business procedure.
8. Submit critical report to officials and general public containing constructive suggestions and procedure incident thereto.
9. Continue educational work until something definite is done to remedy unbusinesslike methods disclosed. Assist officials in installing new systems recommended by the Bureau, or change in former systems.
10. Support publicity by verifiable data, illustrations, budget exhibits, etc.

Trade Notes and Formulæ

Blanching Matt Silver Goods.—Blanch the objects in the ordinary manner, pour over them a paste of potash and water, heat to redness and quench them in water, after which they must be again subjected to blanching.

The Blanching of Silver Goods.—*a.* Boil in sulphuric acid 1 part, water 40 parts. *b.* Boil in cream of tartar 1 part, common salt 2 parts, water 36 to 48 parts. By this means some copper is dissolved from the surface and the articles appear to be coated superficially with pure silver.

To Remove Ink Spots from Colored Fabrics.—Excellent results are said by Renken to be obtained with a mixture of alum 2 parts, tart. dep. (purified tartar) 1 part. The spots are wetted, sprinkled with the powder and brushed. Fresh spots disappear at once; in the case of old ones, two to three applications are necessary. The originator has always accomplished his object and the colors have never been affected.—*Pharm. Ztg.*

Relief Writing Composition.—One thousand parts precipitated chalk, 80 parts white dextrine and 5 parts of glycerine are mixed in a mortar with water in such manner that at first only two-thirds of the chalk is taken, the rest being added gradually. If a pure white is wanted a slight addition of ultramarine will be necessary. Otherwise this composition may be tinted as desired with body colors, which, however, must be added stirred in with water. If it is desired to preserve the color for a long time, a small addition of salicylic acid is necessary.—*Der Drogenhändler.*

Glue for Greasy Paper.—To effect a durable adhesion on greasy paper goods, a specially prepared glue must be used. Such a glue may be made by dissolving 25 part of sugar in 75 parts of water, then adding 6.5 parts of slaked lime and heating the mixture for three days to 158 deg. Fahr. Then allow it to cool, pour it off clear after settling, and make up the evaporated water. In 40 parts of the clear solution, soak 60 parts finely broken Cologne glue for three hours and then heat it in a closed vessel, stirring occasionally, for ten hours in the steam or water bath. The strongly alkaline glue is then neutralized with 20 parts of oxalic acid and finally 0.1 part of dissolved carbolic acid is added. Should the glue be too thick, it can be thinned with acetic acid, 10 per cent of 90 per cent acetic acid to the entire mass. With a glue made in the foregoing manner we can effect a good, durable adhesion on greasy paper goods. For the gluing of highly lustrous goods in the same manner, a specially prepared ahesive must be used, as ordinary glue dries out too much and cracks off. This defect can be easily remedied by adding some chloride of calcium to the glue. This greedily absorbs moisture from the air and consequently never allows the glue to dry out to a brittle condition without, however, impairing its adhesive property.—*Deutsche Drogisten Ztg.*

Bouillon Cubes.—The best grade of the so-called bouillon cubes consists mainly of meat broth, condensed to a pasty consistency. These bouilon cubes contain, therefore, the extractive substances of the meat, and of the necessary vegetables, as well as salt and spices. Quaglio's bouillon capsules, according to Hager, are prepared in the following manner: Meat extract 100 parts; tomato juice, freshly expressed, 50 parts; celery powder, 5 parts; salt, 70 parts; are carefully and thoroughly mixed in the steam bath and concentrated to the thickness of extract. With this extract (2.5 grammes) the lower part of a gelatine capsule is filled, whereas in the upper part 0.5 gramme of bouillon spice-fat is placed, and the one-half is forced over the other. Bouillon spice fat is made by digesting 700 parts of fresh beef fat, 500 parts fresh lard and 50 parts of fresh bouillon spice in the water bath (one hour) and filtering it through a hot warer filter. Other bouillon cubes consist chiefly of meat extract, with a large quantity of salt. Bouillon tablets, which at one time were very popular and were extensively made in the home, were prepared in the following manner: Finely chopped, lean beef. (Some times with the addition of chicken-meat and some ham) was boiled down with calves' feet and the resultant broth, freed from fat, concentrated until it jellied on cooling. Finally it was poured out into molds.—*Pharmazeutische Zeitung.*

Science Notes

The Lowest Temperature on Record.—By the use of a specially constructed apparatus, in which helium was evaporated in a vessel surrounded by liquid helium, Prof. Kamerlingh Onnes has succeeded in evaporating helium at a pressure of about two-tenths of a millimeter. The temperature thus attained corresponds to about 1.8 degrees absolute.

New Acid-proof Material for Vessels, etc.—These vessels, the invention of Dr. W. Gunther, are cast of pure iron oxides. The latter have a high melting temperature and are practically indestructible. Pure iron oxide may be obtained by "blowing" pure molten iron. Apparatus and containers made of this material may be manipulated like other metallic vessels. As compared with that of platinum or quartz vessels, the cost is comparatively low. Acids and alkalies can be manipulated, and salts and organic preparations can be prepared absolutely pure in such vessels. They can also be used for drying and heating substances, which would decompose metallic iron.—*Chemiker Zeitung.*

A Toothbrush Supplied by Nature.—On the island of San Domingo there grows a plant (*Gouamia domingensis*) which in certain parts of the island is dried and powdered by the natives and used as a toothpowder; in other parts it is employed as a toothbrush. The cleansing properties have been attributed to the presence of saponin. Pieces about four inches long are cut off from the stems of the plants and dried. When about to be used they are moistened—just like our own toothbrushes—and the teeth are rubbed therewith. In doing this the end of the piece gets frayed out, giving it the appearance of a toothbrush. The plant is also known and used on Jamaica Island, and in Kingston pieces ready for use can be bought in shops for a trifle.—*Wiener Drogisten Zeitung.*

The Production of Argon.—George Claude points to the fact that it is easier to obtain argon from liquid oxygen than by any other method known. The boiling point of argon (186 deg. Cent.) lies between the boiling point of oxygen and nitrogen. Liquid air oxygen of 96 per cent purity contains about 3 per cent or argon, which means that the argon concentration is three times as high as in air, and therefore the separation can be accomplished without any difficulties. This is done in the following manner: The evaporating oxygen is passed through a copper tubing over glowing copper shavings, which serve to absorb the oxygen; the gas then passes through an iron pipe fitted with magnesia, heated to incandescence, which in turn absorbs the nitrogen. It is then conveyed through a quartz tube filled with copper oxide to remove any hydrogen which may be formed by the moisture. Three liters of oxygen per minute can thus be treated in Claude's apparatus, yielding from four to six liters of argon in two hours.

Artificial Wool.—Artificial wool is manufactured from jute and other plants of the same family. The stalks of the plant are soaked in water, as in the regular treatment of flax and hemp, and the outer fibers are removed by beating the stalks. After washing, they are dried in the sun. The textile fabric which is thus obtained requires to be treated with an oily substance or the like, as this serves to make it supple. Mixtures of whale and other oils were first used in the process, but these give the artificial wool a bad odor so that it cannot be put to all kinds of uses. In a newer process, caustic soda and soap solution are used instead, and this appears to give much more satisfactory results. After drying, if necessary, the jute is carded and woven either alone or mixed with other fibers, such as hemp, flax or cocoa fiber.

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